UMA MODELAGEM DOS PROCESSOS COGNITIVO, EMOCIONAL E MOTIVACIONAL ATRAVÉS DE MAPAS COGNITIVOS DIFUSOS

Universidade Federal de Santa Catarina
Programa de Pós-graduação em
Engenharia de Produção

UMA MODELAGEM DOS PROCESSOS COGNITIVO, EMOCIONAL E MOTIVACIONAL ATRAVÉS DE MAPAS COGNITIVOS DIFUSOS

Lúcia Helena Martins Pacheco

Tese de doutorado apresentada ao
Programa de Pós-graduação em
Engenharia de Produção da
Universidade Federal de Santa Catarina
como requisito parcial para obtenção
do título de Doutor em
Engenharia de Produção.

Florianópolis
2002

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Esta tese foi julgada e aprovada para a obtenção do título de Doutor em Engenharia de Produção no Programa de Pós-Graduação em Engenharia de Produção da Universidade Federal de Santa Catarina

Florianópolis, 21 de outubro de 2002.

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A meus pais, *Wellington* e *Olga*, a meus irmãos,
A meu marido, *Renato*, e minha filha, *Renata*,
Pelo apoio, compreensão e carinho,
Fundamentais e verdadeiros.

Agradecimentos

Há muito a agradecer...

À **Universidade Federal de Santa Catarina**,
À Coordenação de Aperfeiçoamento de Pessoal de Nível Superior **CAPES**
Ao orientador Prof. ***Ricardo de Miranda Bárcia***, Ph.D.
Ao co-orientador Prof. ***Alejandro Rodrigues Martins***, D.Sc.
Ao Prof. ***Suresh Khator***, Ph.D. e à Profª. ***Renu Khator***, Ph.D.
por seu apoio no estágio sanduíche na **University of South Florida**.
À banca examinadora pelas valiosas contribuições fornecidas.
À secretária do PPGEP ***Neiva Aparecida Gasparetto*** por todo apoio recebido.
A ***Rodrigo Becke Cabral*** e esposa por sua gentil acolhida nos EUA.
Ao Prof. ***Paulo Sérgio da Silva Borges***, D.Sc.,
pelo incentivo ao doutorado sanduíche e
por sua disposição em me ouvir e compartilhar suas idéias,
as quais foram fundamentais para a finalização deste trabalho.
À psicóloga ***Angelice Amghebem Dias***
pelo apoio, dedicação e entusiamo, os quais foram
essenciais para elaboração do questionário.
À psicóloga ***Angela De Lucca Schröter*** pelo apoio e colaboração.
Ao Prof. ***Sílvio Serafim da Luz***, D.Sc., pelo apoio,
amizade e gentileza pela ajuda na distribuição dos questionários.
Às psicólogas ***Silvana, Andréia, Maria do Carmo, Ana Luz***
A todos os demais psicólogos que
colaboraram no preenchimento do questionário.
Ao Prof. ***George Vittorio Szenézi***, M.Sc. e à Profª. ***Elisabeth Schramm Szenézi***, M.Sc.,
pelo apoio e amizade importantes na fase inicial do trabalho.
Ao Prof. ***Pedro AlbertoBarbetta***, D.Sc.,
pela amizade e idéias para elaboração do questionário.
Ao Prof. ***Luís Claúdio Villar dos Santos*****,** Ph.D.,
pelo apoio local durante o doutorado sanduíche.
À Profª. ***Clara Amélia de Oliveira*****,** D.Sc., ao Prof. ***Leandro Komosinski***, D.Sc., e
à Profª. ***Carmen Dolores de Freitas de Lacerda***, M.Sc., pela amizade e apoio.
A todo pessoal do ***Depart. de Informática e de Estatística*** **- INE**
pelo apoio e colaboração constantes.
Ao ***GRUCAD*****/EEL** pela disponibilização do software *Microsoft Fortran Power Station*.
E um agradecimento especial a meu marido,
Prof. ***Renato Lucas Pacheco***, M.Sc.,
pela disposição constante em ajudar
no compartilhamento das tarefas domésticas e, especialmente,
no desenvolvimento do programa para tratamento de dados,
o que lhe fez sacrificar muitas de suas horas de lazer.
E a todos os demais que direta ou indiretamente
contribuíram para realização desta pesquisa.

E a ***Deus*** por ter colocado todas estas pessoas generosas no meu caminho
E ter me dado forças para perseverar.

Resumo da Tese apresentada à UFSC como parte dos requisitos necessários para a obtenção do grau de Doutora em Engenharia de Produção

UMA MODELAGEM DOS PROCESSOS COGNITIVO, EMOCIONAL E MOTIVACIONAL ATRAVÉS DE MAPAS COGNITIVOS DIFUSOS

Lúcia Helena Martins-Pacheco

Florianópolis - Outubro/2002

Orientador:Ricardo de Miranda Bárcia, PhD.
Área de Concentração: Inteligência Aplicada
Nível: Doutorado
Palavras Chaves: modelos psicológicos, representação mental, Inteligência Artificial
Número de páginas: 362

Resumo

Baseando-se em teorias cognitivas psicológicas, uma nova maneira de modelar cognição, emoção e motivação é proposta usando Mapas Cognitivos Difusos (Fuzzy Cognitive Maps – FCMs). Nos últimos anos, muitos esforços vêm sendo feitos para integrar emoção em modelos artificiais de inteligência, visando a criação de robôs ou agentes virtuais com traços emocionais. Provavelmente a principal dificuldade na modelagem de emoções provém da variedade de informações e estruturas de conhecimento que são ativadas em seu processamento. De fato, as emoções tomam parte no processamento cognitivo completo, no qual co-ocorrem vários fenômenos mentais e fisiológicos. O uso de FCMs para modelar o processamento cognitivo, emocional e motivacional une as vantagens das redes neurais (paralelismo entre informação) e lógica difusa (uso de variáveis imprecisas). Para implementação desta técnica, definiu-se seis classes de conceitos relacionados com os processos emocionais e motivacionais (*Emoções, Aspectos motivacionais e de personalidade, Meta-objetivos, Aspectos do 'self', Meta-ações e Expectativa*), e um contexto específico (*Ambiente trabalho / escola*), no qual elas ocorrem. Relações causais entre os conceitos (*elos ponderados*), os quais são fundamentais para a técnica de FCM, foram obtidas por meio de um questionário. Um grupo de psicólogos (especialistas) respondeu tal questionário, relacionando todas as possíveis combinações dois a dois entre os 48 conceitos pertencentes às classes anteriormente definidas. Para processar os dados coletados foram desenvolvidos programas computacionais, os quais realizam um tratamento numérico dos dados e a simulação da técnica de FCM. Testou-se vários casos para avaliar o comportamento do sistema FCM, considerando-se a interação entre os conceitos. A qualidade dos resultados mostra bastante coerência em relação às saídas esperadas considerando-se as experiências de *senso comum* e as crenças dos especialistas. Assim, é possível concluir que a ferramenta FCM é capaz de modelar processos psicológicos, possibilitando inferências e previsões sobre aspectos motivacionais e emocionais individuais ou grupais. Então, além da análise estatística e dos testes psicológicos, que são ferramentas comuns em psicologia, a técnica de FCM pode ser também aplicada. Da mesma forma que outras ferramentas matemáticas, ela pode propiciar maior objetividade no trato de assuntos desta área, oferecendo aos especialistas muitas pistas para auxiliar no entendimento da realidade psicológica (individual, social e na tomada de decisão), bem como sobre aspectos de suas próprias crenças.

Abstract of Doctoral Dissertation presented to UFSC as a partial fulfillment of the requirements for the degree of Doctor in Production Engineering

A MODELING OF COGNITIVE, EMOTIONAL, AND MOTIVATIONAL PROCESSES THROUGH FUZZY COGNITIVE MAPS

Lúcia Helena Martins-Pacheco

Florianópolis - October/2002

Advisor:Ricardo de Miranda Bárcia, PhD.
Area of Concentration: Applied Intelligence
Nível: Doctoral
Keywords: psychological models, mental representation, Artificial Intelligence
Number of pages: 362

Abstract

Based on psychological cognitive theories, a new fashion of modeling cognition, emotion, and motivation through Fuzzy Cognitive Maps (FCMs) is proposed. In the last years, several efforts have been done to integrate emotion in the artificial models of intelligence to create robots or virtual agents with emotional traits. Probably the main difficulty in modeling emotions comes from the variety of information and structures of knowledge that are activated in their processes. Indeed, emotions take part in the whole cognitive process, which are concurrent with several mental and physiological phenomena. Using FCMs to model cognitive, emotional, and motivational processings, the advantages of Neural Networks (parallelism among information) and Fuzzy Logic (to deal with imprecise variables) are taken together. To implement this technique, six classes of concepts related to emotional and motivational processes were defined (*Emotions*, *Personality and motivational aspects*, *Meta-goals*, *Aspects of the self*, *Meta-actions*, *Expectancy),* and a specific context (*Environment job/school*), in which they will take place. The causal relations among the concepts (weighted edges), which are fundamental for FCM technique, were obtained by means of a questionnaire. Such questionnaire was applied to a group of psychologists (experts), which relate all the possible two-by-two combinations among 48 concepts belonging to one of those classes. To process the data collected computational programs were developed, which perform a numerical treatment of the data and FCM simulation. Several cases were tested to evaluate the behavior of the FCM system considering the interaction among the concepts. The results have shown quite coherence in relation to expected outcomes based on common sense experiences and in experts' beliefs. The quality of them allows concluding that FCM tool is able to model psychological processes making possible inferences and prediction about emotional and motivational aspects of individual and/or groups. Thus, in addition to statistical analysis and *psychological tests*, which are ordinary tools on research in Psychology, FCM technique could also be applied. Therefore, as what happens with the other mathematical tools, it help to provide further objectiveness in dealing with subjects of this area. It can offer experts a lot of clues to aid in understanding the psychological reality (individual, social, and decision-making process) and also aspects about experts' own beliefs.

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SUMÁRIO

PREFÁCIO

O documento aqui apresentado diz respeito à tese de doutorado de *Lúcia Helena Martins Pacheco*, defendida no dia 21 de outubro de 2002, no programa de Pós-Graduação em Engenharia de Produção da Universidade Federal de Santa Catarina.

Este documento consiste de duas partes:

- a primeira parte apresenta, em português, o texto da tese resumido fornecendo ao leitor as principais idéias do trabalho em um único capítulo;
- a segunda parte é o Apêndice, que apresenta, em inglês, a íntegra do trabalho que foi submetido e aprovado pela banca examinadora, seus apêndices e as referências bibliográficas completas, já com as modificações sugeridas.

Foi escolhida apresentação do trabalho neste formato para atender a exigência da RESOLUÇÃO N° 10/CUn/97, de 29 de julho de 1997, que em seu artigo 49 diz: “Os trabalhos de conclusão serão redigidos em Língua Portuguesa”.

Assim, este formato permite ao leitor uma idéia completa do trabalho de forma resumida. E, se desejado, maiores detalhes do todo ou de partes do trabalho podem ser obtidos recorrendo-se à obra completa no **Apêndice**.

UMA MODELAGEM DOS PROCESSOS COGNITIVO, EMOCIONAL E MOTIVACIONAL ATRAVÉS DE MAPAS COGNITIVOS DIFUSOS

1 Introdução

O texto aqui apresentado corresponde a um resumo da tese de doutorado defendida em 21 de outubro de 2002, no programa de Pós-Graduação em Engenharia de Produção da Universidade Federal de Santa Catarina.

O texto completo, em sua forma original, na Língua Inglesa, conforme aprovado pela banca examinadora, encontra-se disponível no **Apêndice** que acompanha este documento. Os que desejarem maiores detalhes sobre o trabalho desenvolvido deverão recorrer ao texto original. A seguir, uma introdução a este trabalho. As referências bibliográficas citadas neste texto são aquelas que constam em *References*, no mencionado **Apêndice**.

Nos últimos anos, as idéias a respeito de inteligência vêm sendo ampliadas para tornar as emoções parte dos sistemas inteligentes. Os livros “Emotional Intelligence” de Daniel Goleman [Gol95] e “Descartes’ Error” de Antônio Damásio [Dms94] tem influenciado muito esta visão atual de inteligência. Goleman considerou que associar inteligência apenas ao QI (quociente de inteligência) e a fatores genéticos é uma visão estreita da realidade. Um QI alto não garante que alguém terá habilidades de autocontrole, entusiasmo e persistência, motivação e ajuste social. Saber como lidar com as emoções e não ser vítima delas é o maior desafio dos seres inteligentes. Além do que, as emoções afetam o estado físico do corpo, trazendo conseqüências boas ou ruins para a vida das pessoas [Gol95] [Rss93].

Damásio mostrou que o raciocínio é inseparável das emoções porque os circuitos neuronais, responsáveis por ambos, operam em conjunto. Baseado em seu amplo conhecimento do cérebro, ele apresentou uma clara explicação de como a razão e a emoção interagem para criar os processos de tomada de decisão, as crenças, os planos para agir etc. Emoção e raciocínio são mecanismos adaptativos responsáveis por nossa auto-regulação ambiental e adaptação social.

Gardner [Grd95], em sua teoria sobre as múltiplas inteligências, sustenta que a inteligência tem muitas facetas. As mais relevantes, para o presente trabalho, são a "interpessoal" e a "intrapessoal". A "inteligência interpessoal" está relacionada com as habilidades de demonstrar empatia e/ou compreensão com as outras pessoas. A "inteligência intrapessoal" está relacionada com as habilidades de auto-conhecimento, compreensão dos seus próprios sentimentos e emoções e do reconhecimento de seu valor social. Para Gardner, o desenvolvimento destes dois tipos de inteligência é tão importante como o desenvolvimento daquelas mais privilegiadas pelo ensino tradicional, a lingüística e a lógico-matemática. Poderiam ser considerados como duas facetas da "inteligência emocional" proposta por Goleman.

Além disto, nos últimos anos, vem sendo feitos esforços para incorporar emoções nos modelos artificiais de inteligência. Muitos trabalhos vêm utilizando teorias e modelos psicológicos das emoções como fundamento para criação de robôs ou agentes virtuais com emoções. Apesar disto, um modelo preciso dos processos emocionais ainda não foi proposto. As limitações dos modelos psicológicos são repetidas nos modelos artificiais. Provavelmente a principal dificuldade na modelagem das emoções advém da variedade de informações e estruturas de conhecimento que são ativadas em tais processos. Emoções não são fenômenos isolados, mas elas tomam parte do processamento cognitivo como um todo. Mais pesquisas em Inteligência Artificial (IA) e em Psicologia devem ser realizadas com o intuito de se descobrir um modelo mais apropriado para o processamento emocional. Certamente, a IA poderá ajudar em tal tarefa, utilizando ferramentas matemáticas e lógicas modernas, as quais poderiam ser mais satisfatórias para a simulação de tal realidade.

O principal objetivo desta tese é definir um modelo artificial dos processos cognitivo, emocional e motivacional que ajude a entendê-los e avaliar sua influência nas ações e nos relacionamentos humanos. Tais processos não são suficientemente explicados, apesar dos vários modelos que vem sendo sugeridos. Os modelos até agora propostos apresentam limitações, pois eles não levam em consideração o paralelismo e a concorrência entre os processos mentais e não esclarecem como o "conhecimento emocional" é organizado. Alguns autores consideram "estruturas de conhecimento", como "objetivos", "modelos do eu", "modelos do mundo", "modelos dos outros", "crenças" etc., partes importantes do processamento motivacional e emocional. Entretanto, tais estruturas não são precisamente especificadas tornando difícil a sua manipulação computacional. A realidade psicológica humana é rica em detalhes e pode ser analisada sob vários pontos de vista. Juntamente com estes aspectos, a linguagem verbal utilizada no desenvolvimento e explicação das teorias psicológicas é um tanto vaga e permite muitas interpretações. Portanto, novos modelos necessitam ser propostos visando uma teoria unificada da cognição, emoção e motivação.

Este trabalho desenvolveu um modelo da realidade psicológica que poderá ajudar na previsão, análise e planejamento dos aspectos emocionais e motivacionais em contextos escolares e profissionais. O contexto profissional é sempre de interesse da Engenharia de Produção e, mais recentemente, o contexto escolar especialmente no que tange ao "ensino à distância". Tais aspectos psicológicos influenciam fortemente as relações humanas e a energia para agir e, conseqüentemente, afetam o sistema produtivo e o desempenho dos estudantes. Portanto, é essencial compreender e conhecer como lidar com estes problemas, visando melhorar o desempenho humano, otimizando os esforços na realização das tarefas.

A seguir, são comentados os fundamentos teóricos, as principais idéias, os experimentos e os resultados relativos a este trabalho.

2 Cognição, Emoção e Motivação Sob a Ótica Psicológica

Este trabalho fundamenta-se principalmente nas idéias cognição, emoção e motivação sob a ótica da Psicologia Cognitiva. Tal visão fornecerá o suporte teórico para a implementação do modelo computacional a ser definido. Sob esta ótica, o ser humano é considerado um "processador de informações", o qual processa/opera os estímulos externos e internos ao seu corpo e as suas representações mentais. A emoção e a motivação são apenas aspectos que fazem parte do sistema completo de processamento de informações.

O ser humano lida com três categorias de informações: *bottom-up*, *top-down* e representações mentais. A primeira categoria – *bottom-up* - corresponde a todas as informações sensoriais que vão do corpo para o cérebro. A segunda categoria – *top-down* –

corresponde a todas as informações que vão do cérebro para o corpo – impulsos nervosos e hormônios hipofisários – promovendo o movimento e a adaptação corporal. E a terceira categoria corresponde a um conjunto de “construtos cognitivos”. Tais construtos são “estruturas de conhecimento”, que representam experiências prévias organizadas em diversos níveis de abstração. Deste ponto de vista, a emoção e a motivação são informações relacionadas à adaptação corporal, que fazem parte dos “construtos cognitivos”. Os “construtos cognitivos” ou “representações mentais” agregam uma série de informações ou conhecimentos acerca de ações, sinais corporais, categorias lingüísticas, objetivos, planos e assim por diante.

Algumas abordagens cognitivas sobre memória e representação mental, bem como teorias cognitivas da emoção e motivação foram analisadas visando conhecer seu potencial para modelagem computacional. O modelo de Atkinson-Shiffrin [AkS68], o dos níveis de processamento [CkL72], o modelo de Tulving [Tul85] e a abordagem do processamento paralelo distribuído – *PDP*- [McR86] são exemplos de teorias estudadas e que foram citadas por diversos autores [EyK94] [Mtl98] [Klg95].

Igualmente diversas teorias cognitivas da emoção e motivação foram estudadas. Foram analisadas principalmente as teorias propostas por de Bower [Bwr81], Power e Dalgleish [PwD97], Ortony e colaboradores [Otn88][OCC88], Stein e colegas [STL93], Reeve [Rev92] e Ford [Frd92]. Tais estudos destacam a estreita relação entre emoção/motivação e “estruturas cognitivas” como “objetivos” e “planos”.

Gordon Bower [Bwr81] apresentou uma teoria sobre emoções que influenciou muitas outras. Para Bower, as emoções são "nós" de uma rede semântica. Tal rede interconecta idéias, aspectos fisiológicos, eventos e padrões musculares de expressão. Para ele a informação emocional é armazenada na rede semântica na forma de proposições ou declarações lingüística, e os pensamentos ocorrem pela ativação destes "nós".

Power e Dalgleish [PwD97] propuseram um modelo do processamento emocional chamado SPAARS- *Schematic, Propositional, Analogical, and Associative Representational Systems*. Para eles, a chave para entender como o processo emocional opera está na noção dos múltiplos níveis e tipos de "representações mentais", nas quais os conceitos relativos às emoções estão inseridos. De acordo com estes autores, o processamento emocional sempre envolve esta seqüência de fatos: "evento" (interno ou externo), "interpretação", "avaliação", "ação potencial", "mudanças fisiológicas" e "consciência". Nesta seqüência, "interpretação" diz respeito à identificação "do que está acontecendo" e a "avaliação", à ponderação de como alguns objetivos podem ser afetados.

Ortony e colaboradores [Otn88] [OCC88] desenvolveram uma teoria sobre a "estrutura cognitiva das emoções", visando fornecer fundamentos para modelos computacionais. Eles propuseram uma estrutura de avaliação que tenta explicar como as emoções são acionadas. Para eles, as emoções distinguem-se entre si de acordo com o foco da atenção, que pode ser "evento", "agente" ou "objeto". Estes três aspectos são ponderados com valores para produzirem diferentes tipos de emoções. Eles também consideram que os objetivos individuais influenciam no processo emocional.

Stein e colaboradores [STL93] sustentam que a maior tarefa de um indivíduo é monitorar o estado de seus objetivos e preferências que levam para estados de bem-estar. Para eles, as emoções estão intimamente ligadas a violações de expectativas acerca da habilidade de alcançar/manter ou evitar/escapar de estados, atividades ou objetos. A percepção de mudanças inesperadas ou novas informações sobre o estado de um objetivo particular é uma condição necessária para ativar a emoção. Os eventos são sempre interpretados com respeito ao conhecimento anterior das situações e dos planos relacionados. Eles sugeriram um modelo geral dos processos de avaliação e planejamento nas experiências emocionais, os quais iniciam quando um evento acontece. De acordo com as características deste evento, vários processos cognitivos poderão ser disparados para evocar a adaptação corporal e resposta comportamental.

De acordo com Reeve [Rev92], emoções são "construtos psicológicos multidimensionais" que 'amarram' quatro aspectos: "subjetividade", "fisiologia", "funcionalidade" e "expressividade". "Subjetividade" é a experiência interna, a qual é composta de "sensações", "sentimentos" e "pensamentos". Esta pode ser analisada apenas através do auto-relato de um indivíduo. A "fisiologia" corresponde às mudanças corporais devido às atividades do sistema nervoso autônomo e do sistema hormonal. A "funcionalidade" diz respeito aos benefícios individuais que a emoção traz para adaptação e interação do indivíduo com o ambiente circunvizinho. E a "expressividade" está relacionada com as expressões faciais, posturas corporais, vocalizações e convenções sociais que tomam lugar em episódios emocionais. A "expressividade" torna possível a comunicação não-verbal das experiências subjetivas para as outras pessoas. Cada diferente avaliação situacional causa uma diferente reação emocional. Com o aumento do "conhecimento emocional" as pessoas aprendem como melhor avaliar cada evento de suas vidas.

Ford [Frd92] utiliza a "Teoria do Sistema Motivacional" – *Motivational System Theory (MST)* - para conceituar a motivação. Nesta teoria a motivação é definida como "a padronização organizada de três funções psicológicas que servem para direcionar, energizar e regular atividades direcionadas a objetivos". Ele utiliza o conceito de "esquema comportamento episódio" – *behavior episode schema (BES)* – que é uma "representação mental" de uma seqüência coerente de uma unidade de "funcionamento da pessoa no contexto". Isto representa um "pacote integrado" de "pensamentos, sentimentos, percepções, ações, processos biológicos e contextos relevantes envolvendo a busca (*pursuit*) de objetivos similares em contextos similares". Para ele, as pessoas guiam seus comportamentos em novos episódios de acordo com suas experiências similares prévias armazenadas no formato *BES*.

Os autores anteriormente mencionados, entre outros, enfatizam a relação entre motivação/emoção e "objetivos e planos". Os "objetivos" são valorados/ponderados em termos de importância de maneira hierárquica. O valor ou a importância de cada objetivo faz o indivíduo gastar mais ou menos energia para alcançá-lo. Quando alguém percebe algum fator interno ou externo significativo, relacionado a um objetivo particular, processos automáticos podem ser disparados, causando uma adequada adaptação corporal para ir na direção do objetivo desejado, ou na direção oposta, no caso de um objetivo indesejado. Outras representações cognitivas podem também ser ativadas durante tal processamento, sendo estas responsáveis pela diferenciação dos estados emocionais e motivacionais acionados.

Além disso, "diferenças individuais", relacionadas a "traços de personalidade" e a motivos sociais, são fatores que direcionam o comportamento das pessoas diferentemente. Reeve [Rev92] menciona "diferenças individuais", tais como "temperamento" ("extroversão", "procura por sensações" e "intensidade afetiva") e outras relacionadas com algum "padrão de comportamento" ("desejo por controle" e "comportamento tipo A"), como também responsáveis por variação nas reações emocionais e motivacionais dos indivíduos. Baseado nos trabalhos de Murray [Mry38], Reeve também considera que os "motivos sociais", especialmente os "motivos de realização", "de afiliação" e "de poder", juntamente com as diferenças individuais, como causadores das preferências comportamentais de cada indivíduo.

Portanto, com base no acima exposto, pode-se concluir que emoção e motivação são "estruturas de conhecimento" componentes de um sistema completo de processamento de informações que é o ser humano. Elas estão especialmente relacionadas aos processos de adaptação do corpo (sensações, níveis hormonais, energia para ação etc.) que é acionado de forma complexa pela atuação integrada de diversas "estruturas de conhecimento" ou "representações mentais". O processamento emocional/motivacional ativa as "representações mentais" correspondentes aos "objetivos pessoais", "planos", "expectativas", "crenças", "traços de personalidade", "motivos pessoais e sociais" e "necessidades fisiológicas", para descobrir o significado da experiência atual e acionar o comportamento adaptativo e mudanças fisiológicas mais adequadas.

Os modelos apresentados de emoção e motivação são em sua maioria seqüenciais. O modelo de Bower sugere algum paralelismo através de redes semânticas, porém os “nós” são restritos às expressões lingüísticas, o que torna o modelo limitado. O modelo SPAARS de Power e Dalgleish apresenta paralelismo entre as informações, porém entre estruturas cognitivas complexas que representam um alto grau de generalização e abstração. Estes últimos autores sugerem que a abordagem *PDP* parece estar mais próxima dos “processos psicológicos automáticos de baixo nível de complexidade”, como é o caso do processamento sensorial. Eles consideram que novos modelos baseados na abordagem *PDP* precisam ser desenvolvidos para atingir uma adequada teoria dos processos cognitivos.

Portanto, apesar das diversas teorias desenvolvidas para explicar o processo cognitivo-emocional-motivacional, outras novas devem ainda ser pesquisadas para se chegar a modelos mais completos. Novos modelos que incorporem paralelismo, concorrência e distribuição das informações, que lidem com a imprecisão e com estruturas de conhecimentos em vários níveis de complexidade, apontam na direção uma solução, visando teorias mais completas da “realidade psicológica”.

Muitas das abordagens psicológicas correntes usam a Estatística e algumas idéias de IA para obter mais objetividade em suas análises. Possivelmente ferramentas de IA, como por exemplo, Redes Neuronais e Lógica Difusa, poderiam ser uma maneira inovadora de lidar com o paralelismo e imprecisão dos processos psicológicos. No

Apêndice *(Chapter 2)* estão expostos maiores detalhes sobre as abordagens psicológicas aqui comentadas.

3 Modelos Artificiais de Emoção e Motivação

Nos últimos anos a IA vem pesquisando como incluir as emoções em seus modelos de inteligência. A idéia de inteligência sem considerar emoção tem-se demonstrado incompleta, principalmente após os trabalhos de Damásio [Dms94] e Goleman [Gol95]. Ambos consideram os mecanismos emocionais como parte fundamental do processo de adaptação, o qual inclui ajustamento social, autopreservação e a capacidade de tomada de decisão. Assim, a IA busca integrar as emoções como uma parte dos sistemas inteligentes completos.

Os mecanismos emocionais, nos seres humanos e em outros animais, resultam de milhões de anos de processo evolucionário. Conseqüentemente, houve um aperfeiçoamento do processo de adaptação ao ambiente. O pensamento racional surgiu mais recentemente como um sofisticado mecanismo de adaptação. Muitas vezes a inteligência é definida como a capacidade de adaptação. Então, deste ponto de vista, para modelar a inteligência nos sistemas artificiais é necessário levar em conta ambos os mecanismos de adaptação: pensamento racional e emoção.

O desafio da IA tem sido encontrar modelos viáveis do processo emocional que permita implementações computacionais. A Neurociência, a partir da ótica biológica, tem mostrado o quão complexo e integrativo é este processo [Dms94]. Várias áreas cerebrais podem ser acionadas em um "episódio emocional". Portanto, a Neurociência entende o paralelismo e a concorrência entre os processos como uma importante característica das emoções. Por outro lado, a Psicologia vêm propondo diversos modelos para explicar este processo, os quais também apontam na direção de paralelismo e concorrência entre as informações. Cabe a IA propôr novos modelos, ou mesmo implementar os propostos em Psicologia e Neurociência, para promover avanços no entendimento do processo cognitivo-emocional.

Há basicamente três tipos de abordagem de emoção em IA: as que visam produzir "robôs inteligentes e emocionais", as que desenvolvem "mundos virtuais", onde agentes de *software* tem algum tipo de comportamento emocional, e aquelas que não pertencem às anteriores como, por exemplo, no caso do reconhecimento de expressões faciais. Fundamentalmente estas implementações visam obter máquinas ou sistemas computacionais que espelhem melhor o ser humano e/ou que possam melhor interagir com ele.

Porém, apesar de tantos trabalhos nesta área, há muitos aspectos que ainda não estão suficientemente explicados. Vários modelos psicológicos deveriam ser testados, visando obter uma teoria mais geral deste processo. Como dito anteriormente, novas ferramentas de IA, como Redes Neuronais, Lógica Difusa, Algoritmos Genéticos entre outras, podem permitir modelar os processos cognitivo, emocional e motivacional de uma forma mais próxima daquela da qual, de fato, eles o são. **Apêndice** *(Chapter 3)* estão expostos maiores detalhes sobre as abordagens artificiais aqui comentadas.

4 Mapas Cognitivos Difusos para Modelar Cognição, Emoção e Motivação

Os Mapas Cognitivos Difusos (Fuzzy Cognitive Maps – FCM) foram propostos por Kosko [Ksk86] baseado nos trabalhos de Axelrod [Axe76]. Axelrod desenvolveu um tratamento matemático, por meio de operações com matrizes, para seus mapas cognitivos. Um mapa cognitivo é uma maneira da pessoa ou grupo representar seus pensamentos ou crenças a respeito de um domínio de conhecimento limitado. Tais pensamentos são expressos por meio de palavras ou expressões lingüísticas, interligadas por relações simples de causa e efeito (causa/não-causa). Este mapa pode ser considerado como um complexo sistema que modela matematicamente a "estrutura de crenças" de uma pessoa ou grupo, permitindo inferir ou predizer as conseqüências que esta organização de idéias causa no universo representado.

Kosko adaptou o tratamento matemático destes mapas de Axelrod para um tratamento matemático utilizando Lógica Difusa. Os Mapas Cognitivos Difusos – FCM- à semelhança dos mapas cognitivos de Axelrod, são grafos bidirecionais (dígrafos), porém os valores numéricos são variáveis ou conjuntos difusos. Os FCMs são uma boa maneira de representar sistemas complexos que não estão bem definidos. Eles juntam algumas vantagens da modelagem através das Redes Neuronais e de Lógica Difusa. Os "nós" destes grafos são conceitos lingüísticos, representados por conjuntos difusos, e cada "nó" é associado com outros através de "elos de ligação". A cada um destes "elos" é associado um peso numérico, que representa uma variável difusa relacionada com o nível de causalidade entre os conceitos.

FCMs já foram usados em muitos áreas (por exemplo: análise política, sistemas distribuídos, circuitos elétricos, sistemas geográficos etc.), porque eles permitem uma representação rápida ou mesmo detalhada de sistemas complexos. Também permitem associar mapas sobre o mesmo assunto entre si, ampliando assim a representação do conhecimento.

Para se construir um FCM é necessário coletar informações sobre o assunto a ser abordado. Isto pode ser feito por meio de entrevistas ou questionários aplicados a especialistas no assunto, através de informações escritas na bibliografia especializada, através de um desenho de um FCM por um especialista ou mesmo através de uma reunião para discussão entre especialistas. Após a coleta de informações, um engenheiro de conhecimento deverá gerenciar o conteúdo obtido e definir o mais apropriado FCM para aquele assunto.

Quando diferentes especialistas são consultados, eles podem diferir em suas opiniões acerca do peso numérico dos "elos de ligação" ou quais conceitos são realmente relevantes. Eles podem concordar ou não com uma particular organização ou mesmo com o equilíbrio global do FCM completo. Então, o engenheiro de conhecimento pode adicionar os FCMs fornecendo assim uma possível solução para o problema. A superposição dos FCMs de cada especialista tende a fazer com que opiniões conflitantes se anulem e o consenso venha à tona [Ksk91].

FCM apresenta muitas vantagens na modelagem dos processos cognitivo, emocional e motivacional, porque esta ferramenta é capaz de simular operações paralelas (característica das Redes Neuronais) e lidar com imprecisões conceituais através da Lógica Difusa. Um conceito ("nó") pode representar uma "estrutura mental de conhecimento" ("representação mental") que agrega vários tipos de informações e não possuem um limite preciso. Ou seja, um conjunto difuso, devido as suas características, pode ser uma boa opção para modelar as estruturas mentais. Por definição, em um FCM um "nó" – conceito - é um conjunto difuso. Além disto, o processamento integrado e simultâneo de diversas informações em episódios emocionais ajusta-se muito bem ao modelo de um dígrafo. Portanto, pode-se concluir que os FCMs têm um grande potencial para a modelagem apropriada da "realidade mental".

Informações mais detalhadas sobre os FCMs podem ser obtidas no **Apêndice** deste documento *(Chapter 4)*.

5 Uma Abordagem da Cognição, da Emoção e da Motivação através de Mapas Cognitivos Difusos

De acordo com o exposto anteriormente, FCM apresenta um grande potencial para modelagem de processos psicológicos. Porém, esta abordagem propicia o desenvolvimento de diversos modelos. Então, será definido o que os "nós" e os "elos" do FCM representam nesta presente abordagem.

Como mencionado anteriormente, os “nós” dos FCMs representam *conceitos* expressos por uma palavra ou expressão verbal. O objetivo deste trabalho é propor uma modelagem para os processos cognitivo, emocional e motivacional. Portanto, os *conceitos* a serem escolhidos são expressões lingüísticas acerca desta realidade. Ao nível mental, tais processos ativam várias estruturas de conhecimento ou de informações altamente interligadas. Aqui, todas as “estruturas de conhecimento” presentes na mente de um indivíduo serão o Conjunto Universo de suas “representações mentais”. Tal conjunto universo é composto de muitos subconjuntos, de acordo com uma determinada característica ou organização considerada. Assim, um exemplo de uma análise mais restritiva seria: considerando-se um indivíduo com um determinado nível de instrução matemática, pode-se considerar como o seu conjunto universo dos números o dos números complexos, o qual apresenta vários subconjuntos, como o dos números reais, dos números inteiros, dos números primos, dos números irracionais, dos múltiplos de dois etc. Neste exemplo, há muitos subconjuntos e muitas intersecções entre eles. Os mesmos elementos podem pertencer a diversos conjuntos, ou entre alguns conjuntos não haver intersecção alguma. Este é um caso típico de conjuntos clássicos (*crisp sets*) onde os elementos ou pertencem ou não-pertencem a um determinado conjunto. Já nos conjuntos difusos, a pertinência de um elemento a um conjunto é uma função, ou seja, o grau de pertinência de um elemento a um conjunto pode variar continuamente entre o pertencer e o não-pertencer. Portanto, não há um limite bem definido do conjunto.

Voltando as “estruturas mentais” ou “representações mentais”, elas serão tomadas aqui como organizações de conhecimento. Tais estruturas vão desde representações sensoriais até estruturas complexas e abstratas, como por exemplo, a memória semântica, a memória de procedimentos, a memória episódica (modelo de Tulving), os objetivos, o modelo do eu, o modelo dos outros, o modelo do mundo, as reações emocionais etc. Na modelagem aqui proposta, estas estruturas são subconjuntos do conjunto universo de todas as "representações mentais" na mente de um indivíduo. Tais subconjuntos são difusos, pois não possuem um limite bem definido e possuem muitas intersecções (informações comuns) entre si. Eles são bastante abrangentes e representam "classes de conceitos". As instâncias destas classes de conceitos serão os "nós" (*Conceitos*) do FCM pretendido. Tais conceitos representarão alguns aspectos emocionais, motivacionais, da personalidade, dos objetivos, do eu etc., presentes nas "estruturas de conhecimento" de um indivíduo ou grupo de indivíduos. Estes conceitos formam pequenas redes que agregam vários tipos de informações (sensoriais, episódicas, lingüísticas etc.), mas são identificados por meio de uma palavra ou expressão lingüística. Eles são altamente interligados formando uma ampla rede de informações. Já os "elos" do FCM modelam estas interligações, indicando um valor numérico difuso como relação causal entre os conceitos. Esta relação representa o grau de intersecção (*degree of subsethood*) entre os subconjuntos/conceitos, ou seja, o quanto um tem subconjuntos em comum com o outro em termos de relação de causa e efeito.

A proposta deste trabalho foi definir os *Conceitos* com base na bibliografia especializada de Psicologia (abordada no item 2) e pesquisar a opinião de especialistas (psicólogos) acerca da relação causal entre os conceitos escolhidos. As classes de conceitos e os conceitos definidos são apresentados no **Apêndice** (*Figure 5.2, Chapter 5*). Maiores detalhes sobre a abordagem dos processos cognitivo, emocional e motivacional através de FCM pode ser encontrados no **Apêndice** *(Chapter 5)*.

Assim, considerando que FCM é uma ferramenta bastante apropriada para modelagem da realidade mental, em especial dos processos cognitivo, emocional e motivacional, será definida a seguir uma metodologia para construção deste modelo.

6 Metodologia para Modelar os Processos Cognitivo, Emocional e Motivacional através de FCMs

O objetivo principal é definir uma nova modelagem que junte os processos cognitivo, emocional e motivacional e traços de personalidade por meio de um FCM. Para se chegar a tal FCM, a metodologia proposta tem os seguintes passos:

1. definição dos *Conceitos* e seu número;
2. desenvolvimento de um questionário para coletar as informações sobre a relação causal entre os conceitos;
3. aplicação do questionário a um grupo de psicólogos;
4. definição do FCM baseado nas respostas obtidas;
5. análise e avaliação dos resultados.

Foram definidos **48** conceitos para serem os "nós" do FCM. Eles estão baseados principalmente no modelo de memória de Tulving [Tul85], no modelo SPAARS de Dalgleish e Power [PwD97], nos estudos de Reeve [Rev92] e nas necessidades básicas do ser humano definidas por Murray [Mry38]. Cada *Conceito* é uma instância pertencente a uma das 7 classes de conceitos: *Emoções*, *Aspectos da Personalidade e Motivacionais*, *Meta-objetivos*, *Meta-ações*, *Aspectos do Eu*, *Expectativa*, e *Aspectos do Ambiente Trabalho/Escola*. As seis primeiras classes foram escolhidas porque elas representam importantes fatores relacionados aos processos emocional e motivacional. E a última classe representa um contexto mais específico, nos quais os processos cognitivo, emocional e motivacional estão sendo analisados. A definição de um contexto é fundamental para estreitar a extensão dos significados dos conceitos.

Para se obter o peso da relação causal entre os *Conceitos* (valor dos "elos de ligação" do FCM), um grupo de psicólogos voluntários foi consultado através de um questionário. O modelo deste questionário é apresentado no **Apêndice** deste trabalho *(Appendix A)*. O questionário permite pesquisar todas as possíveis combinações dois-a-dois entre os *Conceitos*. As relações serão estabelecidas com uma gradação difusa. O questionário propõe 7 gradações: *Aumenta Muito*, *Aumenta*, *Aumenta Pouco*, *Não Causa*, *Diminui Muito*, *Diminui*, *Diminui Pouco*, selecionadas pelos psicólogos.

A partir dos questionários obtidos foi feito um tratamento numérico-computacional dos dados. Várias aproximações numéricas foram testadas para avaliar as tendências numéricas do sistema e possibilitar a interpretação correta dos resultados. Os resultados obtidos nestas aproximações numéricas foram utilizados na definição do FCM e na simulação computacional do modelo proposto. A partir desta simulação foi avaliada a interação entre os *Conceitos* e o quanto eles espelham a realidade psicológica estudada. Os itens seguintes abordam as questões numérico-computacionais envolvidas e os resultados da simulação. Maiores detalhes sobre a metodologia proposta são encontrados no **Apêndice** deste documento *(Chapter 6)*.

7 Implementação Computacional

Para o tratamento dos dados obtidos e a simulação através de FCM foi desenvolvido um *software* composto de 4 programas escritos na linguagem FORTRAN. Os programas realizam as seguintes tarefas:

1) entrada de dados;
2) correção dos dados e definição dos equivalentes numéricos para as gradações difusas;
3) cálculos estatísticos;
4) simulação do processo psicológico através de FCM..

A tarefa 1) possibilita a entrada dos dados de cada questionário por meio da digitação gerando arquivos como, por exemplo, os mostrados no **Apêndice** *(Appendix B, Tables B1*, *B3* etc.*).* Esta é a base de dados fundamental de toda a implementação e consiste das respostas individuais de cada especialista. A partir dela são gerados os demais arquivos necessários ao tratamento de dados e à simulação.

A tarefa 2) permite que os dados do introduzidos pela tarefa 1) possam ser corrigidos e permite a escolha do equivalente numérico das gradações difusas. O equivalente numérico é o valor numérico que deverá ser associado a cada uma das sete gradações difusas escolhida pelos especialistas para responder cada pergunta do questionário. As gradações difusas são:

- NC – não causa
- AM – aumenta muito
- A – aumenta
- AP – aumenta pouco
- DM – diminui muito

- D – diminui
- DP – diminui pouco

Estas gradações precisam ser associadas a valores numéricos para possibilitar o seu processamento computacional. O *software* desenvolvido permite escolher 5 possibilidades para estas gradações: razão linear (*linear ratio*), razão áurea (*golden ratio*), razão áurea reversa (*reverse golden ratio*), razão quadrada (*square ratio*) e razão exponencial (*exponencial ratio*). No **Apêndice** *(Chapter 7*, item 7.4.1*)* são apresentados maiores detalhes sobre esta questão.

A tarefa 3) gera alguns dados estatísticos acerca das respostas obtidas e a Matriz Média Geral (*General Average Matrix*). Os dados estatísticos gerados pelo *software* contabilizam a freqüência de ocorrência das respostas e o perfil das respostas de cada especialista. Estas estatísticas possibilitam uma visão geral sobre a qualidade dos dados obtidos.

A Matriz Média Geral é a síntese dos dados obtidos dos especialistas, isto é, representa o pensamento médio dos especialistas expresso nas respostas ao questionário. Ela é calculada pela média simples das respostas a cada pergunta. Esta matriz é a "peça-chave" da simulação com FCM. Ela representa o "peso dos elos de ligação" entre os *Conceitos* ("nós" do grafo), ou seja, a relação de causa e efeito dos *Conceitos* entre si. Os valores numéricos desta matriz dependem do equivalente numérico escolhido.

A tarefa 4) é a simulação do processo psicológico através de FCM. Este é o objetivo principal do trabalho. O sistema implementado para a simulação do processo consiste de 5 etapas, a saber:

a) vetor de entrada
b) matriz de "peso dos elos"
c) ajuste *threshold*
d) obtenção vetor de saída
e) realimentação do processo até a estabilização.

O vetor de entrada é de dimensão 1X48. Cada elemento deste vetor representa o grau de ativação de um dos 48 conceitos. Este vetor é multiplicado pela Matriz Média Geral (48X48), a qual é a matriz de "peso dos elos de ligação". O resultante desta multiplicação é um vetor 1X48 ("saída ilimitada"). Este pode apresentar valores numéricos elevados (especialmente com a repetição do processo), o que tende a "mascarar" os resultados qualitativos, ou seja, a característica difusa dos resultados. Para evitar este problema, esta "saída ilimitada" passa por um ajuste numérico através de uma função matemática chamada de função de *threshold*. Esta faz a conversão dos valores da "saída ilimitada" para valores ajustados dentro de uma faixa numérica, aproximando-os de variáveis difusas. O *software* permite escolher 5 funções de *threshold*: regularização, normalização, sigmóide, trivalente e septavalente. Maiores detalhes sobre as funções de *threshold* podem ser encontrados no **Apêndice** *(Chapter 7*, item 7.6.3*)*. O vetor de saída da função de *threshold* é reaplicado como entrada e o processo repetido até a estabilização do sistema. A estabilização é obtida quando a saída se repete em relação a anterior ou um ciclo de respostas iguais ocorre. Se, após um determinado número de iterações, as respostas não se repetirem diz-se que o sistema "não-convergiu". Durante a realimentação do processo até a estabilização, o vetor inicial pode ser mantido ativo e somado ao vetor de saída para ser uma nova entrada (*clamped*), ou ser anulado (*no-clamped*).

Como em qualquer implementação computacional de um sistema complexo, algumas escolhas tiveram que ser feitas, o que resultou em inevitáveis restrições na abordagem do problema. O aparecimento de restrições é inerente ao processo de modelagem devido, neste caso, à necessidade de transformar os valores qualitativos em valores numéricos para seu processamento e, a seguir, retornar os valores numéricos obtidos em informações qualitativas. As várias combinações numéricas propostas pelo *software* visam minimizar as restrições impostas pelo processamento numérico. Para isto, permite-se ao usuário definir quais os parâmetros numéricos que mais se ajustam as suas necessidades. O próximo item aborda as tendências numéricas do sistema a partir de alguns testes realizados. Maiores detalhes sobre as questões associadas à implementação podem ser obtidos no **Apêndice** *(Chapter 7)*, deste documento.

8 Testes e Resultados

Neste item são comentados os resultados de alguns testes realizados com o sistema computacional para se observar suas tendências numéricas. À princípio, os parâmetros numéricos que melhor modelam o sistema psicológico simulado são desconhecidos. Assim, o objetivo destes testes é verificar se, para a mesma situação simulada, há discrepâncias nos resultados com a mudança dos parâmetros numéricos. Vários testes e cálculos foram realizados para se descobrir estas tendências e como isto influenciaria na interpretação dos resultados.

Cálculos estatísticos foram realizados a fim de descobrir aspectos gerais dos dados coletados: o perfil das respostas de cada especialista, a influência de um conceito no sistema e a Matriz Média Geral. A análise destes dados trouxe à tona alguns aspectos qualitativos das respostas, os quais foram importantes na definição dos passos seguintes desta pesquisa.

Foram consultados 12 psicólogos, dos quais nove retornaram o questionário respondido. Quanto aos dados obtidos, pôde-se verificar que a opção *NC* (*não-causa*) foi a mais escolhida, correspondendo a pouco mais de 43% de todas as respostas e 3 psicólogos responderam mais de 50% desta gradação. Seguem em ordem decrescente as gradações *A* (aumenta) – 16,6%, *AM* (aumenta muito) – 16,1%, *DM* (diminui muito) – 9,4%, e as demais apresentam valores menos expressivos. A opção *DP* (*diminui pouco*) foi a menos escolhida por todos os especialistas. Este tipo de análise permite uma noção qualitativa sobre as respostas acerca das gradações e da habilidade dos especialistas lidarem com elas.

Os conceitos também foram considerados de acordo com sua “energia de ativação”. A energia de um conceito tenta expressar o quanto um conceito influencia os outros ou quanto os outros o influenciam. Os testes numéricos demonstraram que os conceitos “Desejo por Poder/Dominação”, “Desejo por Realização” e “Ser Aceito” tem maior capacidade de ativar os outros conceitos, aumentando-os. E os conceitos “Inércia para Mudar/Começar”, “Vergonha” e “Punição” têm mais capacidade de inibir (diminuir) os demais. Por outro lado, os conceitos que mais aumentam em intensidade são “Agir” e “Motivação”. E os conceitos que mais são influenciados pelos outros no sentido de diminuir são “Inércia para Mudar/Começar” e “Confiança no Grupo”. Estes resultados apresentaram-se muito similares para os testes com os diferentes equivalentes numéricos.

Para se analisar as tendências numéricas, foram selecionadas apenas algumas das muitíssimas combinações possíveis entre os parâmetros numéricos para serem testadas. O *software* permite atribuir três valores (-1, 0, +1) para cada posição vetor de entrada ($\mathbf{I0}_{1X48}$), 5 equivalentes numéricos diferentes, 5 diferentes funções de *threshold* e o modo de operação *clamped* e *no-clamped*. Por exemplo, com o conceito 19 (“Desejo por Poder/Dominação”) ativo em +1, 29 combinações diferentes foram testadas com mudanças nos parâmetros numéricos. Também foram testados 28 casos com o conceito 33 (“Inércia para Mudar/Começar”) ativo em +1, e 8 com o conceito 13 (“Introversão”) ativo em +1. Os resultados destes testes permitem concluir que há uma certa independência entre a escolha dos parâmetros numéricos e o comportamento qualitativo do sistema. Para as mesmas condições iniciais (valor de $\mathbf{I0}_{1X48}$), mudanças nos parâmetros numéricos ou diferentes combinações entre eles não influenciam o perfil geral dos resultados.

As funções de *threshold* discretas – trivalente e septavalente – demonstraram expressar o comportamento do sistema de forma coerente com as demais, permitindo uma análise qualitativa mais rápida dos resultados. Também a escolha dos equivalentes numéricos e a escolha entre as operações *clamped* e *no-clamped* não demonstraram influenciar significativamente a qualidade das respostas. Então, os testes descritos no próximo item para análise da interação entre os conceitos irão considerar apenas os seguintes parâmetros numéricos: as funções de *threshold* discretas – trivalente e septavalente -, o equivalente numérico linear e a operação *clamped*. Assim, a interpretação do significado psicológico de cada simulação estará apoiada nestes parâmetros numéricos. Informações mais detalhadas sobre a análise das tendências numéricas podem ser encontradas no **Apêndice** *(Chapter 8)*.

9 Análise da Interação entre os Conceitos

A análise da interação entre os conceitos é o principal objetivo desta modelagem. Os testes numéricos, feitos anteriormente, visavam apenas descobrir quais valores dos parâmetros mais se adequavam a este processo, para melhor refletir a realidade psicológica. Então, foram testadas 23 simulações diferentes através da seleção de valores para os elementos do vetor de entrada $\mathbf{I0_{1X48}}$. Em algumas destas simulações, apenas um conceito (elemento do vetor) foi ativado. Em outras, um conjunto de conceitos foi ativado, tentando representar uma situação específica. Os resultados dos testes realizados são comentados em detalhes no **Apêndice** *(Chapter 9)*.

Nos testes realizados foi percebida uma certa tendência à polarização, de acordo com a acomodação dos conceitos no resultado: "influência desejável" e "influência indesejável". Baseando-se no senso comum, neste sistema é considerada como "influência desejável" a ativação positiva (+1) dos conceitos: "Alegria", "Sentimento de Empatia", "Ir em frente/perseverar", "Agir", "Auto-estima", "Autoconfiança", "Desejo de Realização", "Interesse", "Motivação", "Planejamento e Objetivos", "Organização", "Cooperação", "Satisfação", "Confiança no Grupo", "Dedicação e Sucesso". Da mesma forma, como "influência indesejável" a ativação positiva (+1) dos conceitos: "Tristeza", "Inveja", "Ciúme", "Mágoa", "Vergonha", "Frustração", "Desejo de Vingança", "Ser/Estar Ameaçado", "Arrogância", "Inércia para Mudar/Começar", "Fugir", "Individualismo" e

"Estresse". Verificou-se que este tipo de influência funciona em certa oposição, isto é, quando uma aumenta a outra diminui e vice-versa. O nível de ativação dos conceitos pode variar ligeiramente entre si, em cada teste, mas a tendência à polarização se mantém. Os conceitos não citados anteriormente variam com cada caso testado sem seguir a tendência anterior.

Os resultados obtidos demonstraram bastante coerência em relação às expectativas baseadas na experiência de senso comum. Alguns resultados podem ser questionados, porém não há uma maneira precisa ou única de analisá-los. O sistema FCM proposto, de fato, exprime a síntese do pensamento dos especialistas no que concerne a relação dos conceitos entre si. As simulações com o sistema trazem à tona as crenças dos especialistas, isto é, como eles julgam que os conceitos são interligados. Algumas destas crenças são conscientemente conhecidas, porém outras são como um "padrão escondido" de pensamento relacionado às crenças inconscientes. Os resultados obtidos dão pistas para compreender o que está acontecendo em determinada situação de acordo com o ponto de vista dos especialistas.

Baseando-se nos resultados, pode-se concluir que os FCMs são capazes de modelar processos psicológicos, possibilitando inferências e previsões acerca de questões direta ou indiretamente associadas com os conceitos escolhidos. Também podem fornecer um pouco mais de objetividade ao se lidar com os assuntos de psicologia. Eles podem fornecer aos psicólogos muitas pistas para ajudá-los no entendimento de situações individuais e sociais, no processo de tomada de decisão, bem como de suas próprias crenças. Detalhes sobre a análise da interação entre os conceitos podem ser encontrados no **Apêndice** *(Chapter 9).*

10 Conclusões e Sugestões para Futuros Trabalhos

Este documento apresenta todos os fundamentos teóricos e experimentos práticos utilizados para justificar a modelagem proposta por este trabalho de doutorado.

Tradicionalmente as ferramentas estatísticas e questionários são utilizados em Psicologia Experimental para se chegar a conclusões mais objetivas acerca da realidade mental. Atualmente, várias outras ferramentas matemáticas vêm sendo desenvolvidas e testadas como novas formas de se lidar com imprecisões, questões incompletamente definidas, incertezas etc. Porém, elas ainda são desconhecidas ou muito pouco utilizadas em psicologia. A Lógica Difusa é um exemplo destas novas ferramentas. Ela é muito útil para se lidar com informações lingüísticas e raciocínio qualitativo. O FCM é também uma ferramenta recente que, além da Lógica Difusa, apresenta características das Redes Neuronais. Ou seja, FCMs permitem o raciocínio lingüístico e qualitativo e o processamento paralelo e integrado das informações. Por estas características esta ferramenta se adequa muito bem à realidade psicológica que se deseja modelar.

A originalidade deste trabalho pode ser destacada em três principais aspectos:

1) **as “representações mentais” modeladas com conjuntos difusos**: as “representações mentais” ainda não haviam sido modeladas como conjuntos difusos. Há muitas abordagens psicológicas para memória, organização do conhecimento na mente humana, “representações mentais” etc. Estas abordagens são de fato facetas da organização, armazenagem e acesso da informação na mente de um indivíduo. Vendo as

"representações mentais" como pequenos pedaços destas informações e tomando-as como conjuntos difusos, várias considerações podem ser feitas: pertencem a conjuntos mais amplos e podem apresentar diversos subconjuntos; conjuntos podem apresentar intersecções comuns; apresentam limites imprecisos; podem ser combinadas de diversas maneiras; podem ser representados por uma palavra ou expressão lingüística etc. Certamente, as "representações mentais" mostram estas características difusas, porém até agora elas não tinham sido vistas ou exploradas sob esta perspectiva.

2) **a modelagem da concorrência entre "representações mentais complexas"**: isto significa lidar com "estruturas complexas de conhecimento" como se fossem os neurônios de uma rede neural. De acordo com Power e Dalgleish [PwD97], a abordagem do processamento paralelo distribuído (*PDP*) utilizado nas Redes Neuronais fornece uma melhor estrutura para modelar o cérebro e os processos automáticos de baixo nível, ou seja, os processos sensoriais. Porém, o processamento mental opera conjuntamente os processos automáticos de baixo nível e os processos controlados de alto nível (estruturas de conhecimento mais abstratas). Os "nós" de um FCM podem representar tanto uma estrutura de baixo nível de complexidade como "complexas representações mentais". Tais "nós" estão associados entre si criando redes de informações. Assim, FCMs, à semelhança das redes neuronais, podem operar estruturas de baixo nível de complexidade, mas também modelar informações com alto nível de complexidade expressa por conceitos lingüísticos.

3) **o uso de FCMs para modelar os processos cognitivo, emocional e motivacional**: os FCMs não haviam sido propostos até agora para representar tais processos no nível de complexidade proposto por este trabalho. Conceitos complexos

relativos a estes processos psicológicos foram definidos e se propôs pesquisar e modelar as inter-relações entre eles a partir da opinião de especialistas.

Os aspectos 3) e 2) apresentam uma grande intersecção entre si, embora tenham diferenças significativas. Os FCMs são capazes de representar diversos tipos de organização, e em termos de sistemas psicológicos, muitos modelos usando esta ferramenta poderiam ser propostos operando em mais altos ou mais baixos níveis de complexidade. Assim, o sistema proposto aqui é apenas uma possível modelagem psicológica usando FCM. As abordagens psicológicas consideram alguns construtos cognitivos como objetivos, planos, motivos, expectativa e traços de personalidade como importantes partes dos processos emocional e motivacional. Estes construtos operam conjuntamente gerando comportamentos complexos. Baseando-se nestes construtos, foram definidas "classes de conceitos" relacionadas com os processos emocional e motivacional e um contexto específico. As particularidades da modelagem propostas são caracterizadas pela definição das "classes de conceitos" e de suas instâncias. As instâncias são os "nós" do FCM (conceitos) e as respostas ao questionário dadas pelos especialistas são os "elos causais" entre os conceitos.

A abordagem proposta é também "não-trivial" porque considera não apenas um modelo computacional baseando-se em uma teoria psicológica específica acerca de emoções e motivação, mas uma nova maneira de conceber este assunto. A maioria dos modelos artificiais utiliza apenas uma ou algumas poucas teorias psicológicas. Porém, aqui a modelagem está apoiada numa ampla revisão bibliográfica sobre as teorias cognitivas, conforme é detalhadamente exposto no **Apêndice** *(Chapter 2)*. A ótica da Teoria dos

Conjuntos Difusos e das Redes Neuronais, utilizadas para analisar questões psicológicas, torna-se também uma nova contribuição para a Psicologia. De fato, a Lógica Difusa parece adaptar-se muito bem à realidade psicológica devido à sua capacidade de lidar com variáveis lingüísticas e imprecisões. Os conceitos utilizados como "nós" escondem uma rede de informações associadas. Tais conceitos são conjuntos difusos, que incluem vários subconjuntos de informações relacionadas – sensoriais, semânticas, de procedimentos, episódicas etc. Também, as características das Redes Neuronais associadas aos FCMs incorporar à modelagem o paralelismo e a distribuição das informações.

Um outro ponto que pode ser considerado "não trivial" nesta abordagem está no fato de que a modelagem abre possibilidades computacionais para simular este assunto de uma maneira relativamente rápida e fácil. A IA vem procurando modelos computacionalmente viáveis. Ortony et al. [OCC88] propôs um modelo que se adapta a esta realidade, porém, ele é considerado parcial e incompleto. Pfeifer [Pff88] e Sloman [Slm97][Slm98][SaL98] também definiram as características desejáveis para desenvolver comportamentos emocionais em ambiente computacionais, mas tais sugestões são um tanto parciais e pouco claras.

Uma outra questão que dificulta a modelagem artificial das abordagens psicológicas é a falta de uma linguagem unificada em Psicologia. Através de uma abordagem com FCMs, os conceitos de uma teoria psicológica específica podem ser definidos e relacionados com outros pertencentes a outras teorias.

A abrangência deste modelo é grande porque ela poderia ser aplicada diretamente ou mesmo adaptada para ser útil em diversos contextos. O poder de representatividade desta ferramenta permite flexibilizar sua aplicação para áreas correlatas. Mantendo-se as sete classes de conceitos propostas, é possível mudar suas instâncias ou mesmo mudar algumas classes para se adaptar a um propósito particular. Ela poderia ser utilizada em planejamento, diagnóstico e para previsão de fatos (simulação) em escolas, empresas, terapia etc. A investigação dos "padrões escondidos" no FCM pode mostrar relações entre os conceitos ou situações que eram previamente desconhecidas. Além disto, a flexibilidade da modelagem com FCMs permite simular aprendizado e adaptação por meio de modificações nos conceitos ou mesmos alterações nos pesos numéricos dos "elos de ligação". Por estas razões, este modelo, como está ou adaptado a diferentes circunstâncias, poderia ser utilizado em muitas aplicações em psicologia ou análise do ambiente social.

Assim, além da análise estatística e dos testes psicológicos, os quais são ferramentas comuns na pesquisa em psicologia, a técnica de FCM poderia também ser aplicada para auxiliar a se tratar dos assuntos desta ciência com mais objetividade. Esta técnica é capaz de fornecer aos especialistas muitas pistas para ajudar no entendimento da realidade psicológica (individual, social e no processo de tomada de decisão) e também de suas próprias crenças. De acordo com Kosko [Ksk91], a matriz de conexão de um FCM expressa a estrutura de crenças dos especialistas acerca daquele tema, seus preconceitos, sabedoria, conhecimento ou mesmo sua ignorância.

A confiabilidade, extensão e limitações desta modelagem dependem de quão significantes são os conceitos escolhidos para expressarem a realidade a ser estudada. Um conceito abrange construtos idiossincráticos e significados de senso-comum, ou seja, socialmente partilhados, os quais estão respectivamente relacionados à subjetividade (imprecisão) e a objetividade (precisão). A modelagem difusa usando variáveis lingüísticas (conceitos) tenta espelhar, de forma verbal, a realidade a ser analisada. Assim, os conceitos devem representar esta realidade. Conseqüentemente a confiabilidade, extensão e limitações desta ferramenta dependem do grau de representatividade dos conceitos escolhidos, das relações causais estabelecidas entre eles, bem como da habilidade dos especialistas e do engenheiro de conhecimento de entender e interpretar as saídas numéricas difusas.

Esta ferramenta permite uma abordagem rápida ou mesmo bastante detalhada acerca de um assunto. Uma abordagem rápida pode ser feita através de um dígrafo esquematizado pelas pessoas envolvidas com a utilização de poucos conceitos. Uma abordagem detalhada utilizaria um maior número de conceitos e demandaria um maior tempo para ser elaborada. Neste segundo caso, devido ao grande número possível de combinações, os “padrões escondidos” são de mais difícil acesso e um tratamento computacional dos dados seria exigido. A vantagem, neste caso, seria dificultar o disfarce das informações por aqueles que definem o “peso dos elos de ligação”.

Para futuras pesquisas é sugerido:

- desenvolver uma interface amigável para o *software*, tornando seu uso mais fácil;
- incluir no *software* mecanismos de aprendizagem e adaptação, possibilitando mudar os conceitos (adicionando ou excluindo) ou o “peso dos elos de ligação”;

- testar diferentes aplicações mantendo as 7 classes de conceitos, porém escolhendo instâncias destas classes que são mais significativas para cada caso;
- aplicar o modelo para planejamento ou diagnóstico de problemas e avaliar sua performance, em ambientes particulares (escolas/empresas);
- aplicar este modelo em psicologia clínica como uma forma de registrar as características dos pacientes (personalidade e aspectos emocionais e motivacionais), para se obter pistas para orientação do procedimento terapêutico. O psicólogo poderia construir um FCM ou pedir ao paciente para preencher um questionário. Neste caso, os conceitos escolhidos deveriam ser bem significativos para o paciente;
- pesquisar outras possibilidades de tratamentos numéricos para se obter a matriz dos "elos de ligação";
- sempre que possível, definir os conceitos com aqueles que vão responder o questionário (ou desenhar o dígrafo), a fim de obter uma maior representatividade;
- usar esta ferramenta para definir agentes artificiais com comportamentos emocionais.

Finalmente, baseando-se nos resultados obtidos, pode-se afirmar que a modelagem proposta sintetiza uma nova visão sobre a cognição, emoção e motivação, sendo capaz de simular os processos psicológicos, possibilitando inferências e previsões acerca de várias questões relacionadas. Assim, levando em conta as idéias já exaustivamente comentadas, o grande suporte teórico mostrado e o caráter inovador em tratar deste assunto multidisciplinar, pode-se concluir que este trabalho fornece uma nova e poderosa ferramenta para pesquisa em Psicologia e Ciência Cognitiva.

APÊNDICE

A MODELING OF COGNITIVE, EMOTIONAL, AND MOTIVATIONAL PROCESSES THROUGH FUZZY COGNITIVE MAPS

Universidade Federal de Santa Catarina
Programa de Pós-graduação em
Engenharia de Produção

A MODELING OF COGNITIVE, EMOTIONAL, AND MOTIVATIONAL PROCESSES THROUGH FUZZY COGNITIVE MAPS

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Tese de doutorado apresentada ao
Programa de Pós-graduação em
Engenharia de Produção da
Universidade Federal de Santa Catarina
como requisito parcial para obtenção
do título de Doutor em
Engenharia de Produção.

Florianópolis
2002

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List of Acronyms

AI: Artificial intelligence

ALP: automatic level of processing

ARAS: ascending reticular activating system

ASD: Action Selection Dynamics (framework proposed by P. Maes[1])

BES: behavior episode schema [Frd92]

CLP: controlled level of processing

FCM: Fuzzy Cognitive Map [Ksk86]

ICS: Implicational Level of Interacting Cognitive Sub-systems [Bnd85][TdB93]

MOPS: Memory Organization Packets [Sck82]

MST: Motivational System Theory [Frd92]

PDP: Parallel Distributed Processing [McR86]

RBFCM: Rule-Based Fuzzy Cognitive Map [CjT99]

SIM_AGENT: computational system called toolkit[2] used to explore a variety of such emotional architectures.

SPAARS: Schematic, Propositional, Analogical, and Associative Representational Systems [PwD97] (see Figure 2.2)

TAU: Thematic Abstraction Units [Dyr83]

TOPS: Thematic Organization Packets [Sck82]

T.O.T.E.: Test-Operate-Test-Exit [MGP60]

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[1] P. Maes – "*The Dynamics of Action Selection*" – Eleventh International Joint Conference on Artificial Intelligence, 1989 - cited in [GVI95]

[2] For more information see http://www.cs.bham.ac.uk/~axs/cogaff.html

Chapter 1

INTRODUCTION

In the last years, the notions about intelligence have been broadened to encompass emotions as part of intelligent systems. The books “Emotional Intelligence” by Daniel Goleman [Gol95] and “Descartes’ Error” by Antonio Damasio [Dms94] have highly influenced this current view of intelligence. Goleman considered as a narrow view to associate intelligence only with IQ (intelligence quotient) and genetic factors. High IQ does not guarantee that someone will have self-control, zeal and persistence, motivation, and social adjustment abilities. Knowing how to deal with emotions, and not being their victims is the biggest challenge of intelligent beings. In addition, emotions affect the physical state of the body provoking good or bad consequences in someone’s life [Gol95][Rss93].

Damasio showed that reasoning is inseparable from emotions because the neuronal circuits responsible for both work together. Based on his extensive knowledge of the brain, he presented a clear explanation of how reason and emotion interact to create the processes of decision-making, beliefs, plans for action, etc. Emotions and reasoning are adaptive mechanisms responsible for our self-regulation within the environment and social suitability.

Gardner [Grd95] in his theory of multiple intelligences maintains that intelligence has several facets. The most relevant for this study are the *interpersonal* and the *intra-personal* intelligence. *Interpersonal intelligence* is related to the abilities of showing empathy and/or understanding others. The *intra-personal intelligence* is related to the abilities of self-knowledge, understanding his/her own feelings and emotions, and recognizing his/her social value. For Gardner, developing these 2 types of intelligence is as important as developing the other ones. These 2 types of intelligence could be considered as two facets of the emotional intelligence proposed by Goleman.

Moreover, in the last years several efforts have been done to incorporate emotion in the artificial models of intelligence. Many works have been using psychological models/theories of emotion as basis to create robots or virtual agents with emotions. Nevertheless, a precise model for the emotional processes has not yet been proposed. So, the constraints of the psychological models are repeated in artificial models. Probably the main difficulty in modeling emotions comes from the variety of information and structures of knowledge that are activated in such processes. Emotions are not isolated phenomena but they take part in the whole cognitive processing. More research in Artificial Intelligence (AI) and Psychology has to be carried out in order to find out a more appropriate model for emotional processing. Surely, AI could help in such task providing modern mathematical and logical tools, which could be more satisfactory to simulate this kind of reality.

The main objective of this dissertation is to define an artificial model of the cognitive, emotional and motivational processes that can help understand them and evaluate their influence on human actions and relationships. Indeed, the performance of such processes is not satisfactorily explained, despite of the several models that have been suggested. Previous models have limitations because they do not take into account the parallelism and concurrence among information in mental processes and they do not clarify how “emotional knowledge” is organized. Some authors consider structures of knowledge such as goals, models of the self, models of the world, models of others, beliefs, etc. as part of the emotional/motivational processing. But these structures are not precisely specified making computational manipulation difficult. Human psychological reality is rich in details and it can be seen from several points of view. Besides these aspects, the verbal language used to develop and explain psychological theories is somewhat vague and allows many interpretations. Therefore, new models need to be proposed aiming at a unified theory of cognition, emotion and motivation.

This work has developed a model of psychological reality that could help in planning, predicting, and analyzing the emotional and motivational aspects in professional and scholar contexts. The professional context has always been the subject of studies in Industrial Engineering and, more recently, so has the scholar context, especially the one related to *distance learning*. Such psychological aspects strongly influence human relationships and energy to act and, consequently, they affect the productive system and the students' grades. Therefore, it is essential to understand and to know how to cope with these matters aiming at improving human performance, optimizing the efforts in the achievement of tasks.

In order to develop the issues mentioned above, this work has approached the subject in ten chapters. Chapter 2 presents a review of cognition, emotion, and motivation mainly based on Cognitive Psychology. Aspects related to those issues are analyzed and some authors' models are discussed. Firstly, the idea of human beings as information processors is shown. The environment provides several external stimuli to the human beings' body, which work together with internal parts of the body (*bottom-up information*). Such stimuli are processed by a perceptual mechanism that compares them with the previous knowledge in someone's mind trying to find out matches and to decode the meaning of the information. This processing can reach a high level of complexity. Previous knowledge is organized in structures that connect information with some degree of similarity. Such structures are mental representations or mental models about the world, oneself, other people, how to act, etc. The mental processing attributes a meaning to the bottom-up stimuli, then another set of stimuli is sent from the brain to the body for its adaptation (physical actions and hormonal levels – *top-down information*) and mental images are also activated. The emotional and motivational state, from this point of view, is the resultant energy of such adaptation.

Chapter 2 also presents some cognitive approaches about *mental representation and memory* and *cognitive theories of emotion and motivation*. The main ideas of the Atkinson-Shiffrin's model [AkS68], levels of processing approach [CkL72], Tulving's model [Tul85], and PDP approach [McR86] have been discussed. Moreover, some psychological aspects of emotion and motivation based on Gordon Bower's approach (emotion as a semantic net), Power and Dalgleish's [PwD97] model (SPAARS), Reeve's [Rev92] ideas, Ortony et al.'s model [OCC88], Stein et al.'s [STL93] model, and Ford's [Frd92] approach have also been discussed. In addition, aspects of goals and plans, individual differences related to personality traits and social motives are shown. For several authors these last aspects are strongly related to the emotional and motivational processes.

Chapter 3 provides a summary of several researches related to the artificial modeling of emotion and motivation. It is possible to divide these researches in three categories: implementations that aim at putting emotion and/or motivation in robots; creation of virtual environments with emotional/motivational software agents; and other researches that do not belong to the previous two, e.g., recognizing facial expressions. Artificial Intelligence has been investigating the possibility of including emotional aspects in models of intelligence. From an evolutionary standpoint, intelligence is defined as the capacity of adaptation. The higher mental processes responsible for reasoning and the prediction of events are more recent than emotional processes but both are mechanisms of adaptation. Thus, from this point of view, it is necessary to take into account emotion as part of the whole system of intelligence. Algorithms have been developed to produce robots or software agents with emotional behavior capable of interacting in a better way with human beings. In addition, these researches allow seeing cognitive and emotional processes in a more objective way, which helps to understand humans' psychological reality. However, it is necessary more research in this area to achieve a unified and general theory about such matter.

Chapter 4 presents a discussion of Fuzzy Cognitive Maps and their potential to model emotion and motivation. Kosko [Ksk86] combined Axelrod's ideas [Axe76] on cognitive maps and Fuzzy Logic creating Fuzzy Cognitive Maps – FCMs. FCMs are fuzzy directed graphs (digraphs) used to represent causal reasoning, which gather some advantages of Neural Networks and Fuzzy Logic together. The nodes of these graphs are linguistic concepts represented as fuzzy sets and each node is associated with others by links called edges. Such edges have a weight (fuzzy variable) that is related to the level of causality among the concepts. This tool is used in several areas (e.g., policy analysis, distributed systems, electrical circuits, geographic systems, etc.) because it enables a quick representation of some complex system. Also, it allows associating different maps about the same subject, enlarging the representation of knowledge. FCMs seem to have many advantages in modeling cognitive, emotional, and motivational processes because this tool is able to simulate parallel operation and to deal with fuzzy sets and fuzzy variables as nodes and edges of the graph. A concept (node) could represent a knowledge structure (mental representation) that aggregates several kinds of information and does not have a precise boundary. Then a fuzzy set could be a good way to represent such psychological structures. In addition, FCMs provide concurrence among information, which is a characteristic of mental processes. The mathematical treatment of FCMs makes possible to evaluate the influence of one concept on all the others and predict the effect of some situation in the activation of the set of concepts.

Chapter 5 approaches the use of FCMs to represent cognitive, emotional and motivational processes. This chapter describes the relation of psychological processes and FCMs capacities to model. The nodes of FCMs are concepts, which are represented by means of words or linguistic expressions. This verbal representation can be conceived as hiding a net of interconnections that is the meaning of the concept. This net aggregates semantic, procedural, and episodic structures of knowledge as well as analogical (sensorial) information. It also works as mental representations of something and it shows vagueness and no precise boundary. Also, it shares information with several other ones. Therefore, Fuzzy Logic and Fuzzy Sets seem to fit well in these features. The edges, which are the causal relationship, represent the *degree of subsethood* among the concepts. This causal relation is also a fuzzy variable and represents how much a concept influences another one. The edges working together represent the concurrence among the concepts as a neuronal network.

Chapter 6 describes the methodology that was chosen, and it specifies the proposed model. The main objective is to generate a new model that gathers cognitive, emotional, and motivational processes and some traits of personality together by means of FCMs. To achieve such objective, 48 concepts were defined to be the nodes of an FCM. Such concepts are mainly based on Tulving's [Tul85] ideas, Power and Dalgleish's [PwD97] SPAARS model, and Reeve and Murray's studies [Rev92][Mry38]. Each concept is an instance belonging to one of 7 classes of concepts: *emotions*, *personality and motivational aspects*, *meta-goals*, *aspects of the self*, *meta-actions*, *expectancy*, *and aspects of the environment job/school*. The 6 first classes were chosen because they represent important factors related to emotional and motivational processes. The last class was chosen to represent a more specific context in which the cognitive, emotional, and motivational processes are analyzed. The definition of a context is fundamental to narrow the extension of the meaning of the concepts. The weighted edges among the concepts, which are fundamental for the FCM technique, are obtained by means of a questionnaire. Such questionnaire has been applied to a group of psychologists (experts), which should relate each concept with other ones. All the possible two-by-two combinations among the concepts can be searched, which correspond to a total of 2304 relations.

Chapter 7 discusses the implementation issues related to computational processing. It describes the software developed for the processing and numeric treatment of the data collected. The software generates the database in a file fashion, some general statistics and the “General Average Matrix”. This matrix has been taken as an FCM connection matrix (or weighted edges matrix) and it synthesizes the experts’ thoughts. FCM simulation is the innovational modeling proposed by this research. Some practical issues of the implementation have been explained and justified as well as their influence on the outcome of interpretation.

Chapter 8 performs several calculations to figure out the numeric tendencies of the system and how it could influence the interpretation of the results. Statistical calculations have been carried out here in order to bring out qualitative aspects of the responses, which are important in the definition of the direction of further steps. The numeric tendencies have been analyzed with the aim of knowing how different set of numeric equivalents and different threshold functions affect the system responses. The results have indicated somewhat independence of the system behavior in relation to the choice of numeric parameters. For the same input values, the system general responses have demonstrated a kind of pattern profile of even varying numeric attributes.

Chapter 9 analyzes the interaction among the concepts. Several cases are suggested to evaluate the behavior of the FCM system. Such cases try to simulate how a concept or a set of concepts influences entire system. The results are stressed with the aim of interpreting the possible psychological reality that was evoked. The obtained results quite coherent in relation to expected outcomes based on common sense experiences and on experts’ beliefs. Indeed, the FCM system expresses a synthesis of experts’ beliefs about the relationship among the concepts. The results give clues to understand about what is going on in a situation according to the experts’ standpoint.

Chapter 10 summarizes the whole document and it assesses the *originality, non-triviality, reliability, extent*, and *limitations* of the proposed modeling and the outcomes. The *originality* of this research is evidenced by the analysis of mental representations as a fuzzy set and the application of FCM to model cognitive, emotional and motivational processes. Mental representations have not been modeled yet as a fuzzy set. The advantage of this modeling is to allow representing features of these psychological constructs: vagueness, lack of a precise boundary, and the interconnection among mental representations. Also, FCMs have not been used yet to model cognitive, emotional, and motivational processes putting complex structures of knowledge together to simulate the mental reality with parallelism and concurrence. Thus, it is a new conception that can be a good contribution as a new fashion to address such questions.

This modeling is *non-trivial* because it has made a very comprehensive analysis of the recent approaches of the models of cognition, emotion, and motivation. The majority of the artificial models of these issues have held their theoretical support in one or a few psychological approaches. Here a new integrative conception of cognition, emotion and motivation has been synthesized, which due to its power of *representativeness*, makes possible its employment in many applications. For example, it can be used in planning or diagnosing technique in schools, companies, therapy, etc. The analysis of the "hidden patterns" in FCMs allows seeing beyond the surfaces the matter. In addition, changes in the weighted edges and/or addition of new concepts can simulate learning or adaptability. Therefore, this model and its improvements, suited to different situations, might be very useful in many applications in Psychology and social analysis.

Reliability, *extent*, and *limitations* of this modeling depend on the choice of the concepts and how much meaningful they are to represent the reality to be analyzed. Each concept hides a psychological idiosyncratic construct but part of this shares a common social meaning. The boundary between vagueness (imprecision) and objectiveness (precision) is a trade off associated with the individual mental representation and the shared common social meaning. Here each concept has been modeled as a fuzzy set and understood by means of Fuzzy Logic. This kind of modeling suits very well the linguistic variable, and it also fits mental representations treated as concepts. Therefore *reliability*, *extent*, and *limitations* are related to how that fuzzy modeling mirrors the reality to be analyzed, as well as in the experts' ability of understanding and interpreting the outcomes.

The quality of the obtained results allows concluding that the FCM tool is able to model psychological processes making possible inferences and prediction about some issues. Thus, in addition to statistical analysis and *psychological tests*, which are ordinary tools on research in Psychology, the FCM technique could also be applied. Hence, as what happens with other mathematical tools, it would help to provide further objectiveness in dealing with subjects of this science. It can offer to experts a lot of clues to aid in understanding the psychological reality (individual, social, and decision-making process) and also about experts' own beliefs.

Therefore, supported by the ideas shown above and the explanations along this document, it can surely be concluded that it justifies a doctoral dissertation due to its great theoretical support and its innovative character in dealing with such subject.

Chapter 2

COGNITION, EMOTION, AND MOTIVATION A PSYCHOLOGICAL REVIEW

2.1 Introduction

The objective of this chapter is to provide theoretical support based on studies in Psychology for development of a computational model of emotion and motivation. Some cognitive approaches will be discussed in order to extract ideas that make possible to get a feasible and original model to be computationally implemented.

Firstly, human beings are analyzed as information processors and motivation and emotion are just aspects of this system. Human beings deal with *bottom-up* and *top-down* information, and mental representations. The first corresponds to sensorial information that comes from the body to the brain, the second corresponds to information that comes from the brain to the body, and the last correspond to a set of cognitive constructs. Such constructs are knowledge structures, which represent prior experiences organized in several levels of abstractions. In this context, emotion and motivation are information mainly related to bodily adaptation that are part of cognitive constructs. These cognitive constructs aggregate information or knowledge about actions, bodily signals, linguistic categories, goals, plans and so on. This chapter presents a summary of the main ideas about these cognitive constructs and their organizations.

Secondly, some cognitive theories of emotion and motivation are presented as well as some physiological aspects of this subject. The organization of the information at the biological level, especially in the nervous system, gives support to the emergence of psychological reality. It is particularly reviewed Bower's theory about emotions [Bwr81], Power and Dalgleish's model and ideas [PwD97], Ortony et al.'s theory [Otn88][OCC88], Liwag et al.'s model [STL93], Reeve's standpoint [Rev92], and Ford's considerations

[Frd92]. These studies have especially pointed to a close relation between emotion/motivation and goals and plans.

Goals are valued in terms of importance in a *hierarchical* fashion. The value or importance of a goal makes an individual spend much or less energy to attain it. When someone perceives some external or internal meaningful factors related to a particular goal then automatic processes can be triggered causing an adequate bodily adaptation to go towards a desired goal or, in opposite direction, to an undesired one. Other cognitive representations can be also activated during such processing and these are responsible for making differentiations about the kind of driven emotional and motivational state.

Some individual differences and motives can also influence the particularities of emotional/motivational reactions. Some individual differences mentioned by Reeve [Rev92] such as temperament (*extraversion*, *sensation seeking*, and *affect intensity*) and others that are related to some behavioral patterns (*desire for control* and *type A behavior*) are reviewed here. Other individual differences are social motives, specially *achievement*, *affiliation* and *power* motives. These motives and personal traits generate certain behavioral preferences in each individual.

In the last part of this chapter, aspects, which are considered more relevant to generate a computational model and the constraints that the previous theoretical models have shown, will be summarized.

2.2 Human Being as an Information Processor

Information Theory emerged in 1948 with Shannon and Weaver [Shn49]. This approach is a mathematical modeling aimed at providing solutions for technological matters related to the accuracy of information transmission. Besides dealing with questions in Engineering, this theory influenced several other human communication areas, such as Language and Psychology (e.g., [Ltj96][Stb92]). The idea of considering human beings as sender and receiver of messages, and as information processors began to be used by Cognitive Psychology.

This approach influenced several authors' thoughts (e.g., [NwS72][Pff88]), which considered human beings as information processors. Some cognitive approaches have been using this idea to develop models trying to explain how human beings acquire, process, transform, store, and behave themselves according to internal and external information that they are exposed to.

Mandler [Mdr85] said that the human information processing approach -HIP- was the first step of contemporary Cognitive Psychology as the evolution of Behaviorism. Stimuli (S) became inputs and responses (R) became outputs and a higher level of complexity replaced the chain of events that mediated the input-output relations. Moreover, some ones took into account the occurrence of parallel and distributed processing increasing the complexity of the older models and producing a better representation of the human beings' mental processes.

Dilts [Dlt83] holds that information is organized in hierarchical levels to explain how subjective experience is structured. Tom Stonier [Stn92] considered the informational approach as the organizational origin of the Universe, having the same status as matter and energy. He explains that the evolution of the Universe started with the *Big Bang*, as an increase of the complexity of information, and continues up to today with the intelligent systems. The pre-existing complexity is used to reach a higher degree of complexity, and exponentially increasing the information and decreasing the entropy.

Information is structured in several levels of complexity by human beings, beginning at the biological level, through genes, hormones, sensorial organs, etc.; up to the psychological level. This last one is also structured in several levels of representational complexity. Figure 2.1 shows a model that stands for the information processed by human beings.

Figure 2.1 shows an architecture that generically represents all the information that human beings process. The body of the human being receives a great quantity of stimuli that comprehend environmental stimuli and the external/internal perception about his/her own body. According to Luria [Lra91], this information is acquired through sensorial external channels (visual, auditory, external kinesthetic, gustatory and olfactory) and through internal kinesthetic channel, and then the whole information is transferred to nervous system to be processed. The internal kinesthetic channel corresponds to all the inner sensorial information of the body. This inner sensorial information is constituted of two parts: interoceptive sensorial information (related to visceral sensations) and proprioceptive sensorial information (related to the position of the body in the space). All the sensorial information (external and internal) that comes from the body constitutes the *bottom-up* information, also called *afferent stimuli*. This set of information, which represents input data, is transferred through the peripheral nervous system (Physical level) to the brain, and then processed in another level of complexity called Psychological level or Mental level. Matlin [Mtl98], among others, cites the *Sensorial memory*, which has a high capacity of storage, and holds acquired information by the sensorial channels. This memory holds the information during a few seconds and part of that is transferred to the *Short-term memory*.

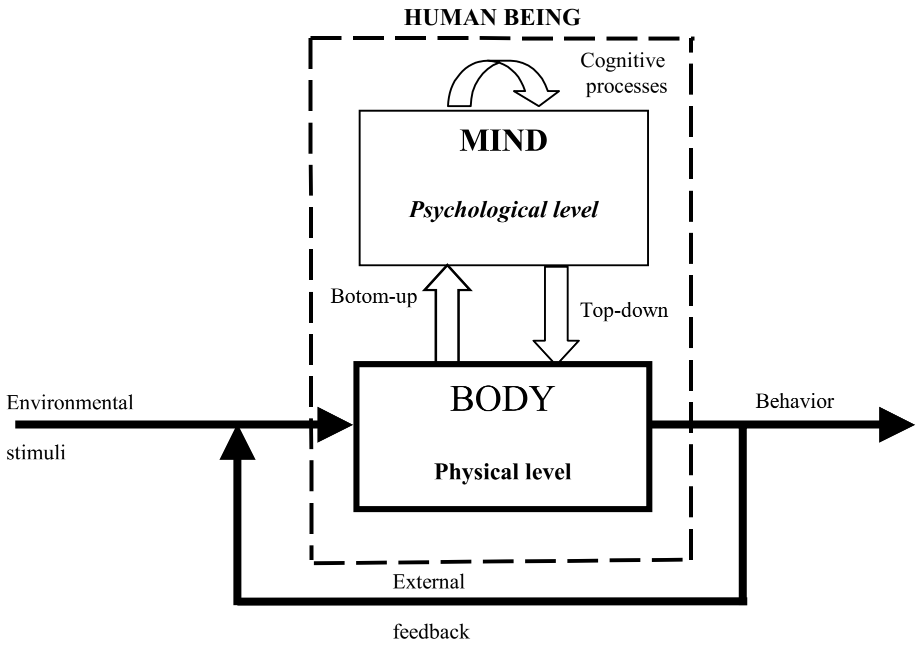


Figure 2.1 – General functional architecture mind-body.

In the Psychological level, several parallel processes might be going on. The result of these processes is a set of adaptive information about which behavior must take place and about internal state of the body. The set of information from the Psychological level to the Physical level is called *top-down* information, also called *efferent stimuli*.

The nervous and circulatory-endocrine systems are informational systems and they intermediate the relationship between the Physical level and the Psychological level. According to Rossi [Rss93], the nervous system is not the single informational system that the human being has. From an evolutionary point of view, the nervous system is the most recent and the fastest informational system but the circulatory and the endocrine systems are also informational systems and they operate via messenger molecules. The hypophyse and the limbic-hypothalamic system can be considered “transducers” of information between the central nervous system and the circulatory-endocrine system and that set is responsible for the psychosomatic communication between the Psychological level and the Physical level. Thus, the body-mind system processes a set of information that is not only electric (neurological) but also biochemical (through circulatory-endocrine system) [Dms94].

The curved arrow on top of Figure 2.1 represents all the cognitive processes that take place in the Psychological level. It corresponds to all the mental operations that occur in the mind such as recognizing (perception), recalling, memorizing, reasoning, imagining, etc. These processes operate *bottom-up* information and activate other mental processes and bodily processes. Some of these mental processes give feedback to other mental processes being able to reach high levels of abstraction from the *bottom-up* sensorial information. Furthermore, some cognitive processes might be activated without any *bottom-up* stimuli [Lra91][Vyg86]. Cognitive processes organize the analogical information that arrives in the brain (*bottom-up* stimuli) in several levels of abstraction. If it is necessary, other new information is generated through reasoning and imagination. From the point of view of processes control, these operations might be defined as a sophisticated adaptive system control having a powerful capacity of learning.

Figure 2.1 is a general model that helps us to see the relation between body-mind from the perspective of information processing. But it is necessary to use other architectures or models aiming at understanding how cognitive processes elaborate information. Next, several questions related to the cognitive process will be explained in order to discuss the main psychological ideas that support this research.

2.3 Mental Processing Levels

Several authors that research neuronal networks consider that mental processes are highly parallel (e.g., [McR86]). Some of them assume at least two levels of processing: one related to awareness functions and the other associated to bodily control and automatic processes (e.g., [Slm97]).

Some authors (e.g., [SdS77][Klg95]) make distinctions between *automatized* and *controlled* processes. For Power and Dalgleish [PwD97], *controlled* cognitive processes are which demand an attentive control to be carried out. On the other hand, through repetition or practice, some *controlled* processes may not require attention to be executed becoming *automatized*. Especially some emotional responses may become automatized. Those emotional responses are not merely obtained through repetition during an individual's history but they become automatic to guarantee the survival of the species during its evolutionary history. The vast majority of the cognitive and social processes have the potential to become automatized including those related to the generation of emotions. It is important to stress that *controlled* process and *automatized* process are extremes of a continuum with meaningful intermediate positions. Logan [Lgn80] suggests that *automatic processes* are a way of direct access to past solutions in memory.

Power and Dalgleish [PwD97] also make distinctions between *unconscious* and *conscious* psychological processes in order to explain the emotional processing and some mental disturbances. They assume that the key to understand how the emotional processes operate is the notion of multiple levels and types of representation of emotional related concepts in the mind and the existence of *unconscious* and *conscious* systems. *Unconscious* processes correspond to *automatized* ones and *conscious* processes correspond to *controlled* ones.

According to Joseph LeDoux [LDx98], from an evolutionary point of view the *unconscious* processing (non-verbal) is older and more general than the *conscious* ones. He assumes that the novelty in the evolutionary scenery is the natural language, which is the expression of the conscious processes. The ancient functions are kept preserved in the present human being and some of them are responsible for the emotional processing.

Howard Shervin and colleagues [Srv96] have performed several studies to show the dependence between several psychopathologies and *unconscious* conflicts as well as to develop methods to address this question. They have found some evidence, among others, about the relations between *unconscious* process and physiological aspects. The unconscious paradigm has been a fundamental support of several psychotherapeutic currents, in special psychoanalysis. The psychoanalytic lines and the hypnosis therapy, [PEw96][Rss93][OjS96] among others, use the idea of *unconscious* as an assumption to explain the psychological disorders and to develop therapeutic methods to solve that problem.

Damasio [Dms99] considers the existence of a set of underpinning processes and the *conscious* processes. For him these last are divided in several levels of complexity. Also Sloman [Slm97] has suggested that there are, at least, *two levels of mental processing*: one related to bodily, instinctive processes and conditioned responses; and another related to selective attention. This latter is elaborative and process some pieces of information.

Based on the last concepts it can be said that there are two levels of mental processes: *conscious* or *controlled* processes and *unconscious* or *automatized* processes. The first ones are related to the ideas of attention mechanisms and *Working memory* [Mtl98], operating with a limited set of information. The second ones carry out mental activities that control the functioning of the body (autonomous nervous system and endocrine system), automatic behaviors that are features of humankind as well as some other learned behaviors that were acquired through conditioning (repetition).

2.4 Perception and Attention

Perception is a complex cognitive mechanism that consists in recognizing the meaning of the *bottom-up* information [Lra91][Mtl98][EyK94][Klg95][JkN98]. The bottom-up information is compared with some mental representation to find one (or a group) that matches it. This mechanism makes analyses and synthesis tasks emphasizing some traits and trying to categorize the bottom-up sensorial information in some prior acquired knowledge. Known objects are rapidly identified and new ones can require complex processes of reasoning.

According to Luria [Lra91], perceptive activity is almost never limited to one sensorial modality but it puts together a set of sensorial information to be investigated. Through the internalization of language and concepts [Vyg86], perception is mediated by learned psychological constructs. These constructs represent several levels of abstraction and generalization of prior experienced situations. So, the current experience becomes mediated by prior psychological constructs instead of a direct relation between the individual and the environment. Some inferences based on prior knowledge and the present situation is carried out to recognize the *bottom-up* signals.

Attention is a cognitive process related to the capacity of selecting a set of information dealing with that information through voluntary concentration. Some studies in this field try to find clues about how that mechanism work, about individuals performing simultaneous tasks, and so on [Mtl98][EyK94]. Attention is based on innate neurological mechanisms, and during an individual's development it is mediated by psychological constructs. However, an individual keeps the involuntary attention mechanisms [Olv93]. Filter theories (e.g., [Bdt57][Nrm68]) have tried to explain how selection and attenuation of information occur based on the sensorial memory. Baddeley [Bdl86] related attention mechanism as a function of *Short-term memory*.

2.5 Memory and Mental Representation

The concepts of memory, knowledge and mental representation are very closely related but researches used to separate them and approach each one from different points of view. This work is going to be based on more usual ideas about memory and mental representation to develop a computational model. Only a non-usual approach in Cognitive Psychology was added, considering *submodalities* techniques adopted by Blander and colleagues.

2.5.1 Memory

According to Cognitive Psychology ideas [Mtl98][EyK94][Klg95][JkN98], there are four main approaches to memory (or knowledge). These approaches represent different attributes without any competition among them, only considering different points of view. They are *Atkinson-Shiffrin's model*, *Levels of Processing approach*, *Tulving's model* and the *Parallel Distributed Processing (PDP)*.

Atkinson-Shiffrin's model [AkS68] considers memory divided in three different storages: *Sensorial memory*, *Short-term memory* and *Long-term memory*. The *Sensorial memory* is a high capacity storage system that keeps sensorial information (*bottom-up*) without processing for about 2 or 3 seconds. A small part of the information of this memory goes to the *Short-term memory* to be processed.

The *Short-term memory* takes about 7±2 information, coming from the *Sensorial memory* and it keeps it for about 30 seconds. The information is usually acoustic, semantic and/or visual code. In some approaches this memory is divided in three parts: a *phonologic* *loop*, a *visual-spatial memory* and a *central executive* that integrates these information with what is activated in the *Long-term memory*. The *central executive* also deals with attention, planning and behavioral coordination.

The *Long-term memory* stores the content from the *Short-term memory*. The *Long-term memory* has high capacity of storage and holds information of decades as well as information acquired few minutes ago. The context in which information is stored influences the recall in *Long-term memory*. Retrieve is facilitated for the kind of information in which the current mood is congruent with the information was stored in *Long-term memory*. The contents present in the *Long-Term memory* are relatively permanent but through learning mechanisms some new information can be combined to the older ones or even changed [EyK94].

The information in *Long-term memory* is semantically codified in nets of meanings organized through linguistic categories. There is also an *autobiographical* memory that keeps information about the events that someone has experienced which defines the personal history of each one and his/her identity. In this kind of organization, the more meaningful emotional events are kept with a vast quantity of details. And there is another type of organization called *schema* that represents generalizations or stereotypes about proceedings in common situations, relations, and generic objects.

The *Levels of Processing Approach* [CkL72] proposes one *deep level* and one *superficial level* of processing. The *superficial level of processing* involves analyzing sensorial features and the *deep level of processing* requires analyzing of the meanings. The latter favors associations with other prior information and allows more retention than the first one.

Tulving's Model [Tul85] classifies the nature of memory in three types: *Semantic* memory, *Episodic* memory and *Procedural* memory. *Semantic memory* deals with the organization and knowledge about the world. This organization is established through the formation of linguistic concepts and interrelations among them. *Episodic memory* handles information about the events that are gathered according to some idiosyncratic pattern of similarity. And *Procedural memory* represents generalizations about *how* and *when* to do something. This procedural knowledge comes from abstraction and generalizations from lived experiences by an individual during his/her personal history. Making an analogy with computational systems, *Procedural memory* is like a set of programs, which define patterns of physical and mental behaviors.

And finally the *Parallel Distributed Processing Approach (PDP)* [McR86], which uses paradigms of *Neural Networks* from Artificial Intelligence. This approach proposes a net of links of communication among unities called *neurons*. These *neurons* represent a computational simulation of the real neurons. The links are pondered with weights that represent in some way the learned information. The operation of these nets is highly parallel, i.e., a set of operations simultaneously occurs. The propagation of the information takes place when an adequate level of activation is attained then other unities might be activated or inhibited. This approach has called attention to the parallelism of the cognitive operation. Information becomes impressed in neuronal networks as pondered connections among the neurons. The most frequent information creates stronger connections that other ones less used. These connections and their weights are equivalent to knowledge learned by an individual, and they could be changed according to other new information that arrives in the network.

2.5.2 Mental Representation

There are several currents in Cognitive Psychology that try to explain the mental representation, e.g., *Schemas* [Brt32][RmO77], *Scripts* [ScA77], *Frames* [Mnk75], *Memory Organization Packets (MOPS)* and *Thematic Organization Packets (TOPS)* [Sck82], *Mental Models* [JhL83], *Implicational Level of Interacting Cognitive Sub-systems* (ICS) [Bnd85][TdB93], and *Thematic Abstraction Units* (TAU) [Dyr83], among others. In some of these approaches ideas of knowledge and mental representation are mixed.

Power and Dalgleish [PwD97] have made a detailed review about the models mentioned above, and they proposed a division of mental representation and some kinds of knowledge to explain the emotional process. They assumed three formats of mental representation: *analogical*, *propositional* and *schematic*. These formats represent levels of abstraction of the mental representation. The *analogical level* is related sensorial modalities, which are olfactory, auditory, gustatory, visual, proprioceptive, and tactile. This level of representation has a close relation to the external reality and internal body sensations. The *propositional level* is constituted of more abstract entities, which represent ideas that can be expressed in any natural language. To characterize these non-language-specific representations studies usually make use of the logical system of predicate calculus. *Schematic level* represents higher-order ideational content that cannot be directly expressed in natural language. It corresponds to higher-level structures of knowledge. For

Dagleish and Power [PwD97], this level represents *domains of knowledge* in an individual's mind about *model of the self*, *model of others*, *model of the world* and representation of *goals*. Some more details about the latter will be discussed next.

Blander, Dilts and others [AdA87][BdM88][Dlt98][Dlt90], have used ideas of mental representation to carry out some therapeutic techniques. They consider that the information in a subjective representation is directly related to someone's sensorial experience. Mental representations use the same sensorial modalities of the *bottom-up* information. They argue that people represent the world in the same way that they perceive it. They assume that the kinesthetic channel represents internal and external tactile body sensations, and the auditory channel represents all the sounds that someone can hear. Speech is a kind of special auditory information. Through speech and language it is possible to code practically all other sensorial information operating at different levels of abstraction of the real world. In this approach, they pay special attention to a specific sequence of sensorial representations that a person uses to process information. This sequence is called *strategy*. They figured out that the intensity of meaning holds a direct relationship to *submodalities*. *Submodalities* can be classified as a form of detailing the mental representations and qualifying/quantifying these ones. The experience of these authors has shown that human beings use strategies at the *submodalities* level to differentiate between subjective representations. For example, the mental subjective code that distinguishes past from future (e.g., spatial relations), fear from courage (e.g., still or moving images), happiness from sadness (e.g., bright or dark images), etc.; can be surveyed through analyzing an individual's representation at the *submodalities* level. For this, the person has to be in an introspection state and tell the therapist what he/she envisages in his/her mind. For therapists, emotion and motivation are mainly related to personal patterns of internal kinesthetic *submodalities*. Table 2.1 provides an idea about *submodalities*.

Table 2.1. *Submodalities* distinctions.

Visual	Auditory	Kinesthetic
Color/black and white	*Location*	*Quality*
Brightness	*Pitch*	*Location*
Contrast	*Tonality*	*Intensity*
Focus	*Melody*	*Movement*
Texture	*Inflection*	*Direction*
Detail	*Volume*	*Speed*
Size	*Tempo*	*Duration*
Distance	*Rhythm*	
Shape	*Duration*	
Border	*Mono/stereo*	
Location	*Speech*	
Movement		
Orientation		
Associated/dissociated		
Perspective		
Proportion		
Dimension		
Singular/plural		
Panoramic		

2.6 Cognitive Theories of Emotion and Motivation

2.6.1 Some Physiological Aspects

For a long time emotions were just taken as automatic answers of the organism to its adaptation to environment. In neurophysiologic terms, it was considered that the hypothalamus, the limbic area and the amygdala (older evolutionary parts) were the only responsible parts for the emotional processes. Nowadays, several studies in neurophysiology (e.g., [LiT95][Dms94]) have shown the relationship of some cortical areas in the processing of emotions. Cortical areas are considered responsible for the so-called higher cognitive processes, which are intentional actions, reasoning, abstract thoughts, and so on.

Damásio [Dms94], starting from his studies on cerebral lesions, concluded that several areas in the cortex and neo-cortex are related to emotions. He considers that processes of emotion and feelings are an integral part of the neural machinery of biological regulation, which is constituted by homeostatic controls, impulses and instincts being essential for the orientation of social behavior. So, the brain that probably prevailed in the natural selection could have been that in which the subsystems responsible for reasoning and decision-making stayed intimately associated to those subsystems that were related to the biological regulation. Possibly, this was the way that evolution has taken the due to the role of those subsystems have in the survival of humankind. He also considers those mechanisms as indispensable for the acquisition and the normal operation of the cognitive processes. Mechanisms of biological regulation are intimately related to the cognitive process allowing development of supra-instinctive strategies of survival (personal and social) facilitating a larger flexibility of adaptation to the environment. He also comments that mental representations are the result of the complex integration of the neural activity.

Joseph LeDoux [LDx93] has analyzed the emotional networks in the brain. He has concluded that the amygdala plays a central role in emotion, integrating information of neocortical areas and sensorial areas:

> "Once the amygdala is activated, it can set into motion a variety of motor systems to control emotional responses appropriate to the meaning of stimulus. (….) Its anatomical connections suggest that it can be activated by simple features, whole objects, the context in which objects occurs, semantic properties of objects, images and memories of objects, and the like. Any and all of these may therefore serve as the critical trigger information for emotional arousal. (…) amygdala is somewhat blind as to the nature of stimulus that activates it, since primitive sensory features are

potentially as capable of activating the emotional system as complex thoughts." (Joseph LeDoux.:[LDx93], page 112)

Goleman [Gol95] attributes that the emotional processing goes on at the oldest part of the brain due to the necessity of faster processing of information during some dangerous or threatening situations. At this time, prior strategies or some typical behaviors have to be carried out to preserve the individual.

Thus, studies in neurophysiology demonstrate the need of the cognitive consideration of emotion, based on the mental representations that emerge from the neurophysiologic process. Rossi [Rss93] assumes that there is a continuous and bi-directional flow of information between the mind and the body, interacting with one another. This information is not exclusively neurological but also biochemical (hormones, neurotransmitters, neuropeptides, and substances secreted by the immunological system). The mental representations, resulting from the interaction of all these information, as well as the semantic weight (meaning) that is activated will carry out a corporal state, i.e., an emotional state.

2.6.2 Cognitive Aspects of Emotions

Several current psychological approaches have been assuming cognitive aspects of emotion and motivation. These approaches have begun to accept a broadened idea about what means cognition. These have added sensorial signals to verbal representations to analyze the whole information that human beings are able to process at the mental level.

Next, some of these ideas that could give support to develop a computational model are illustrated.

Gordon Bower [Bwr81] proposed a theory in which emotions are represented as nodes of a semantic net. The net of connections would be related to ideas, with physiologic systems, with events, and with muscular patterns of expression. The emotional material is stored in the semantic net under the form of propositions or statements and the thought occurs by the activation of the nodes. The nodes can be activated by internal or external stimulus and the activation is spread out in a selective way to the related nodes. Conscience consists of a net of nodes that is activated above a threshold value. In his awarded paper "Mood and Memory" [Bwr81], Bower has described some experiments in subjects using hypnotic suggestion to investigate the influence of emotions on memory and thinking. He has concluded that people exhibited mood-state-dependent memory, and emotions heavily influenced such cognitive process as free associations, imaginative fantasies, social perceptions, and snap judgments about others' personalities. In his associative network theory, an emotion serves as a memory unit that can enter into associations with coincident events. Activation of this emotion unit aids retrieval of events associated with it. According to Eysenck and Keane [EyK94], the Bower's concepts have strongly influenced most recent research, even though it is considered a limited theory.

Power and Dalgleish [PwD97] have made a comprehensive review of several cognitive approaches to emotional processes. Among others, they have analyzed some cognitive theories of emotion that they called network theories. According to them, network theories of emotional process "have too many theoretical limitations and inadequate supporting data. In their place, the emergent properties of massively *parallel distributed process network* may more likely to provide a better framework for the brain and low-level automatic processes, though the types of PDP networks currently available may need to be substantially modified before an adequate theory is achieved" (in [PwD97] pg. 112).

For Power and Dalgleish, the key to understand how emotional processes operate is the notion of *multiple levels and types of mental representation* in which *emotion-related concepts* are inserted. For them, mental representations exist in three formats, which are *schematic*, *propositional* and *analogical.* These forms belong to three main domains of knowledge - *self*, *others* and *world*. According to these authors, the components of the emotional processes always involve: *event (external or internal), interpretation, appraisal, action potential, physiological change, and conscious awareness*. In this sequence, "interpretation" means identifying *what is going on* and "appraisal" is the evaluation of *how* some goals might be affected. Goals are the temporal dimension of representations that someone desires to attain or not in the future. They propose a model labelled SPAARS (Schematic, Propositional, Analogical, and Associative Representational Systems) that is shown in Figure 2.2.

This model assumes *two routes* to the generation of emotion: *the schematic model route and an associative automatic route*. The first one consists of the analysis of the higher-order meanings (schematic level). In this route an appraisal (or cycles of appraisal) is done by means of inferences about the implications of a given event for an individual's goals. The result of this process might lead to the generation of emotions. The *propositional* level usually interacts with the *schematic* level during the interpretation phase of analysis of meaning. The second route is the *associative* level, which automatically triggers the emotional response. The automatic generation of emotion is due to emotional learning that someone acquires through the repetition of similar events with the same succeeded strategy of action. This learning is not only related to an individual's history but also to the species' evolutionary history. Some similar events that, at first, are analyzed through the *schematic* level of meaning may generate, by repetition, automatically emotional processes.

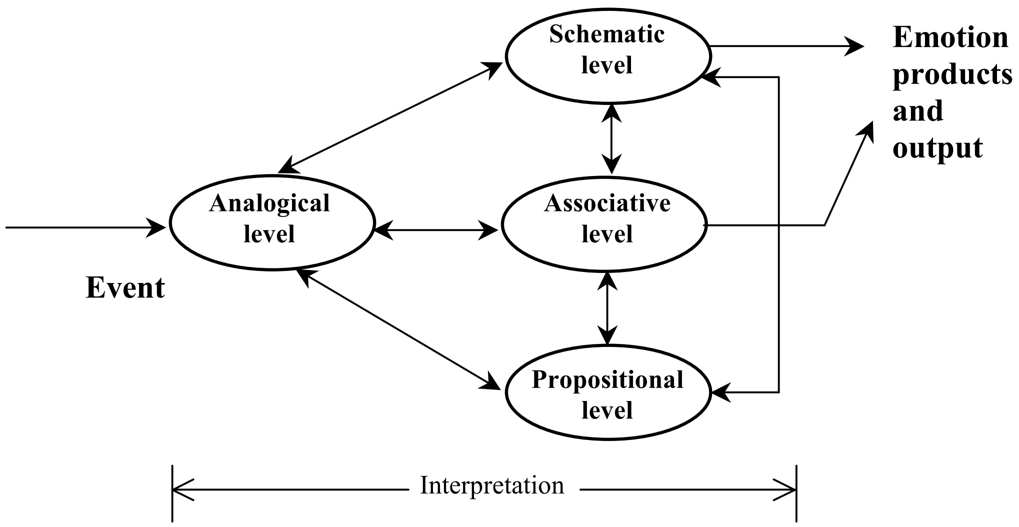


Figure 2.2 – SPAARS model of emotions (modified from Power and Dalgleish [PwD97] page 178).

The idea of an automatic pathway can be related to physiological arousal that some authors (e.g., [Hbb55][Ads90][Mdl67]) used to refer. These physiological changes could happen before an awareness appraisal of the event allowing a faster bodily readiness for some urgent action, if it is necessary.

According to Reeve [Rev92] emotions are multidimensional psychological constructs that bind together four aspects: *subjectivity*, *physiology*, *functionality* and *expressiveness*. *Subjectivity* is the internal experience, which is composed of sensations, feelings and thoughts (cognitions). This *subjectivity* can be only analyzed by means of self-report. *Physiology* corresponds to the bodily changes due to the *activity of autonomic and hormonal systems*. *Functionality* is related to individual benefits from emotion. This last aspect allows the individuals to be more effective in his/her interaction and adaptation with the environment surround. *Expressiveness* is related to the *facial expressions*, *bodily postures*, *vocalizations* and *social conventions* that take place in an emotional episode. *Expressiveness* makes possible to communicate in a non-verbal way any subjective experience to other people. Each different situational appraisal prompts to a different emotional reaction. With an increased "*emotional knowledge*" people learn how best to appraise each of life events.

Ortony, Clore and Collins [Otn88][OCC88] developed a theory on the *cognitive structure of emotions* laying the foundation for a computationally tractable model of emotion. Their theory was based on a synthesis of cognitive theories of appraisal that consists of two generalizations: *arousal* and *appraisal*. They proposed a structure of appraisal that tries to explain how emotions are triggered generating emotional states. They also considered that subjective goals have influence on the emotional process.

They [OCC88] assumed that emotions are distinguished from one to another on the basis of their attentional focus that can be: *events*, *agents* and *objects*. These three aspects are "valenced" to produce different kinds of emotions. Class of *emotions events based* is

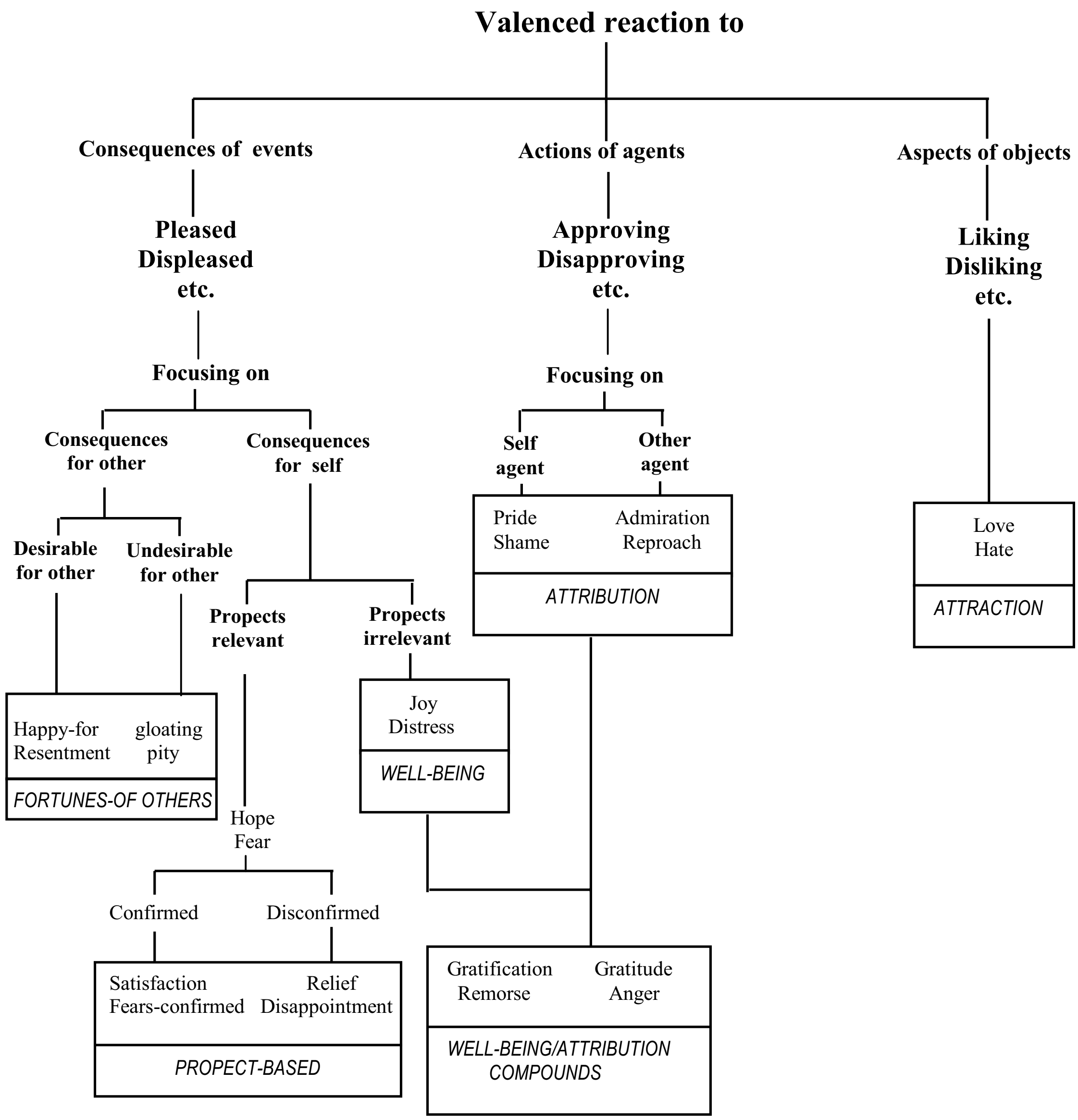


Figure 2.3 – Global structure of emotion (modified from Ortony, Clore and Collins [OCC88] page 19).

"valenced" as *desirable* (pleased) events or *undesirable* (unpleased) events. Class of *emotions agents based* is "valenced" as *praiseworthy* (approval of agents actions) or *blameworthy* (disapproval of agents actions). And finally, class of *emotions objects based* is "valenced" as *liking appealing objects* (attraction) or *disliking appealing objects*. They consider that *goals*, *standards* (*beliefs*), and *attitudes* are implicated in the cognitive appraisal of emotional process. Ortony, Clore and Collins' concepts have influenced some studies in Artificial Intelligence (e.g., [UHH98], [Cle94]) due to their aim at supporting computational models of emotions. Figure 2.3 shows a diagram that allows the visualization of these ideas.

Stein, Trabasso and Liwag [STL93] have held that the major task of individuals is to monitor the status of valued goals and preferences that lead to states of well-being. According to them, emotions are intimately linked to violations of expectations about the ability to attain/maintain or avoid/escape states, activities, or objects. The perception of unexpected changes or novel information about the status of particular goals is a necessary condition to elicit emotion. Events are always interpreted (meaning analysis) with respect to prior knowledge of situations and plans.

They suggest a general model of the evaluation and planning processes in emotional experiences, which begins when an event occurs. According to the features of this event, several cognitive processes might be triggered to evoke the bodily adaptive and behavioral response. Figure 2.4 shows this model. Next, the description done by the authors is transcribed:

> "The sequence begins on the left side of the figure with the current state of the person involved. A precipitating event then occurs. In order for this event to have any effect, it has to be attended to and perceived. If it is encoded, orienting and attentional arousal is triggered. The person tries to assimilate the event into a prior belief structure. If the content contradicts or is discrepant from what the person believes, then automatic arousal is evoked. If there is low or no discrepancy, the event is assimilated without arousal. If the event is evaluated as discrepant, however, further

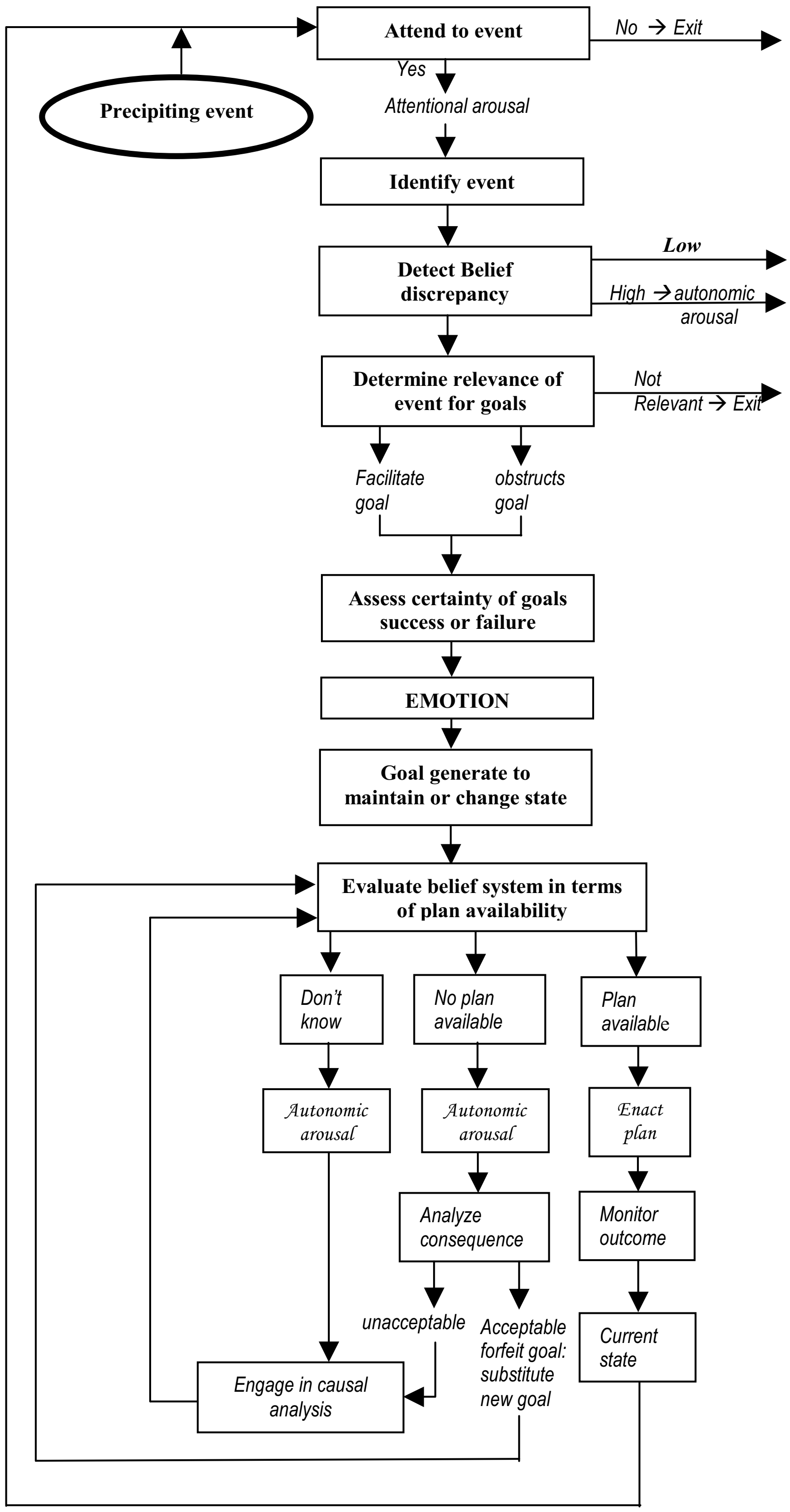


Figure 2.4 – A general model of evaluation and planning processes in emotional experience (Stein, Trabasso & Liwag [STL93] page 298 – modified).

understanding of the event and the determination of its relevance for existing goal states must be made.

Three outcomes of relevance determination can be produced: The event can be evaluated as (1) obstructing goal, (2) facilitating a goal, or (3) not relevant to current goal states. If facilitating or obstruction is present, the person then assesses how the goal success or failure is in the circumstances. If it is certain, then a desire is generated to maintain a valued goal or avoid an undesirable state, or a desire is generated to reinstate the goal that failed or escape the state that now exists. To do this, a person must determine whether or not a plan is available to achieve the desired goal. There are three possible outcomes here: (1) the plan is available; (2) the plan is not available; or (3) the person does not know any plan.

If a plan is available, then it is enacted, and outcomes of the plan of action are monitored and evaluated with respect to the original goal. If the plan is found not be available, then autonomic arousal occurs, and the person analyzes the consequences of the goal failure that transpired earlier. If the negative consequences of goal failure are acceptable, then the person may substitute a new goal and abandon the previous one. If, on the other hand, the consequences are unacceptable, then a causal analysis of the situation is made. If the person did not have a plan to begin with, autonomic arousal occurs, and the person engages in causal analysis of the circumstances that have led to changes in goal state. Causal analyses then lead to reassessment of plan availability and/or generation of a new plan. If one becomes available, then it is enacted and monitored with respect to outcomes of the actions toward goal success or failure." (Stein, Trabasso & Liwag [STL93] pages 297, 299)

This model of emotional experience was described here because it could make possible to define algorithms that simulate the emotional process. But details about how to represent goals, plans, beliefs, etc. would have to be better specified in order to develop a feasible computational model of emotion and motivation.

2.6.3 How Many Emotions Are There?

One question that someone frequently asks is about how many emotions there are. Researchers have adopted different numbers of emotions, some of them consider between 5 to 10 basic emotions. More complex emotions are the result of a mix of these basic ones. Studies by Ekman (e.g., [Ekm73][EpF75][Ekp92][Ekm94]) about facial expressions of emotion in different cultures have strongly influenced studies in this area. For the objectives of this present work, five *basic emotions* will be considered, which are *fear*, *sadness*, *anger*, *disgust* and *happiness* and others as deriving from these, according to how Power and Dalgleish have proposed [PwD97].

2.6.4 Cognitive Aspects of Motivation

There are several approaches to analyze motivation (e.g., [Rev92] [Frd92]). Some of them take into account biological questions, others cognitive and/or social questions. For the objectives of this present work motivation has been analyzed from a cognitive point of view. In it cognitive representations aggregate, among others, information about *how* someone acts upon the environment towards some attainment. These cognitive representations are psychological constructs that bind together similar experiences to accomplish similar goals.

According to Reeve [Rev92], cognitive theory of motivation focuses on mental processes, or “thoughts”, as causal determinants of actions. Cognitive motivational psychologists are interested in the relation between cognition and consequent sequence of actions. Cognitive motivational constructs define a picture in which motives and behaviors are embedded in a continual flux of cognitive activity. Among the most researched cognitive constructs are the following: plans [MGP60], goals [LSS81], dissonance [Fst57], schemas [OCC88], expectancies [Vrm64], appraisals [Lzr66], and attributions [Wnr86].

Reeve proposes that external events supply sensory experience, which are processed through the nervous system. This

> "sensory information is attended to, transformed, organized, elaborated upon, and held in mind while relevant information is retrieved from memory to assist in information-processing flow. Based on our understanding of the meaning of such information processing, we build up expectancies (…), construct goals, (…) formulate plans, and (…) so forth. Our expectancies, goals, and plans are active agents that give rise to motivational phenomena in sense that they direct our attention and behavior toward a particular course of action and away from other possible courses of action. Once the behavioral activity is carried out, it gives rise to outcomes (e.g., success, failure, improvement) that are attended to, appraised, and explained. This outcome-generated cognitive activity further adds to the active information-processing flow to provide an ongoing cognitive regulation of behavior" (Johnmarshall Reeve, *Understanding motivation and emotion*, page 175 [Rev92]).

In Reeve's point of view, the causes or motives to energize a behavior in a determined direction could be *plans*, *goals*, *physiological* and *social needs* or *emotions*. Plans and goals are further approached in some details. Physiological needs are related to bodily processes, such as, hunger and thirst and social needs are mainly related to achievement, affiliation and power motives [Mry38][MCR49]. Finally, emotions are motives that maintain the internal bodily conditions in an adequate way to adapt the actions according to internal or external demands.

Ford [Frd92] uses the concept of motivation based on his Motivational System Theory (MST). In this theory, motivation is defined as "the organized patterning of three psychological functions that serve to direct, energize, and regulate goal-directed activity: personal goals, emotional arousal processes, and personal agency beliefs". (Martin E. Ford Motivating Humans, page 3 [Frd92]). He also uses the concept of *behavior episode schema* (BES), that is, a mental representation of a coherent sequence of unitary person-in-context functioning. "It represents an integrated "package" of thoughts, feelings, perceptions, actions, biological processes, and relevant contexts" [Ibidem page 26] involved in the pursuit of similar goals in similar contexts. People guide their behavior in a new episode according to their *prior similar experiences* stored in BES format.

Another aspect considered in motivation is *expectancy*. *Expectancy* is a subjective appraisal of the probability of attaining a specific goal [Rev92]. Based on past experiences someone guesses about the possibility of some event or outcome to happen. This belief carries out a particular behavior, which produces a particular outcome. For Tolman [Tlm59] and Lewin [Lwn35], individuals distinguish objects as positively or negatively valued. *Expectancy* and value determines direction for behavior. Positively valued objects make the individual approach these objects and negatively valued objects make the individual avoid them. *Expectancy* might be a powerful source of motivation, affecting the intensity and persistence of behavior.

2.6.5 Plans and Goals

Plans and goals are fundamental questions in cognitive approaches of emotion and motivation. Both are motives that direct the action and energize behavior towards an attainment. Some ideas about this issue relating them to cognitive constructs with motivation and emotion will be discussed next.

Miller and colleagues [MGP60] developed a model, called T.O.T.E. (Test-Operate-Test-Exit), about how human beings operate when performing some action. They believe that people have representations of ideal states of their behavior, environmental objects, and events. When people find a mismatch between their ideal state and their present state, they take plan of action to find a match with the ideal state represented in their minds. This mismatch or incongruity is motivational and the plan is a problem solving action to attain congruity with the ideal representation. In the T.O.T.E. model, Test is the comparative phase of the present state with ideal state and Operate is related to the action to be taken to attain the match. After this action a new Test is done. If the mismatch continues, then the person adjusts his/her behavior and performs the Operate phase again. These two phases are continually repeated until the match is found and then the Exit phase is executed. Some researchers (e.g., [Dlt83][Rev92]) have adopted the T.O.T.E. model but assuming that the plans may be adjusted to get faster congruity.

For Power and Dalgleish [PwD97], the mind is best conceptualized as a functional, *goal-directed* system. Goals are heuristic temporal representations of future states that someone wants to attain or not. Goals are *hierarchically* organized and they can have a *facilitatory* or *inhibitory* relationship. In their model of domain of knowledge about self, others and world they suppose that beyond self goals there are a set of goals shared between self and other domains of knowledge. These last ones might be thought of as social standards and related to the Freudian idea of superego.

For Tolman [Tlm59], behavior reflects cognitive processes in which a person is always utilizing hypotheses, expectations, and strategies to reach goals and avoid obstacles. For him, expectancies are units of knowledge (e.g., facts, beliefs) stored in memory that are activated by significant events. By means of repetition of environmental sequences people learn to predict "*what leads to what*" and by means of association to formulate a "cognitive map" of the environment.

For Locke and colleagues [LSS81], goals can enhance performance if they are specific and have some degree of difficult and challenge, otherwise they become ineffective. Effective goals make the individual pay more attention to his/her tasks and to mobilize more effort and develop new strategies to accomplish his/her goals. A feedback mechanism is also important to monitor goals attainment, to adjust the performance and to evaluate if that goal should be kept or rejected.

There are some goals that more time is spent to achieve – *long-term goals* - then it becomes useful for people to create series of *short-term goals*. These *short-term goals* are chained together to attain a more complex goal. This strategy is also favorable for feedback mechanisms allowing easier adjustments towards the attainment of the *long-term goal*. According to Ortony, Clore, and Collins [OCC88], goals might constitute a complex framework as a lattice structure. At the top of lattice is the most abstract (as long-term) aspiration and at the bottom are the most concrete (and short-term) aspirations. Each aspiration is linked to a "causal flow" in which the accomplishment of one aspiration (goal) increases the possibility of achieving another.

2.6.6 Individual Differences

Reeve [Rev92] takes into account individual differences related to motives to act in a way or direction instead of another. He approaches some questions related to personality characteristics, social motives and clinical perspectives of motivation. A simplified review of his ideas seeking to support a computational model with some traits of personality is shown.

Reeve [Rev92] attributes differences in biological make-up as responsible for different temperaments and personalities. These differences make more or less excitable of an individual's brain, autonomous nervous system and endocrine system. Because two systems are closely associated to emotional and motivational response, some emotion and motives to act become differently expressed among individuals. Reeve also considers that these traits are stable response dispositions. The temperament and personality characteristics that he assumes are *introversion/extroversion*, *sensation seeking*, *affect intensity*, and *control beliefs* (*desire for control*, and *type A behavior pattern*). He also takes into account the differences in the social motives, such as *achievement*, *affiliative*, and *power* motives.

Physiological aspects, according to Eysenck [Eyc67], characterize *extroversion/introversion*. The neuronal structures in the brain responsible for the physiological arousal need different levels of stimulation to be activated. Extraverts need strong levels of stimulation, and introverts need lower levels to arouse their *ascending reticular activating system* (ARAS). This fact creates different patterns of self-regulation to control their arousal associated with external stimuli. These characteristics make the introverts better in performing vigilance tasks and lesser susceptible to boredom than extraverts, also with more restrained behavior. On the other hand, extraverts show greater ability for the social behavior and more attracted for competitive situation.

Another trait is the necessity for novel, complex sensations and experiences that characterize *sensation seeking* [Zkm78][Zkm79]. A high *sensation seeker* looks for continual stimulation avoiding routines. This trait is usually linked to extroversion.

The strength with which individuals experience their emotion varies in intensity [DLE85][LDr87][LDE86]. "*Affect intense*" individuals, like *extraverts* and *sensation seeker*, also have a chronically under-aroused nervous system. This kind of individuals experiences extremely their emotions to reach an optimal level or arousal.

Control beliefs are related to someone's expectations about their influence over life events. The authors take into account two control beliefs: *desire for control*, and *type A behavior pattern*. Desire for control is related to the motivation that someone has in controlling life events [BCp79]. People high in the desire of control prefer making their own decisions, preparing for situations in advance, avoiding dependence on others, and assuming leadership roles in group settings. People low in the *desire for control* tend to avoid responsibilities and prefer having others make decisions for them. A *type A behavior pattern* is characterized by competitive achievement strivings, time urgency, and easily evoked hostility [FdR74][Gls77].

2.6.7 Social Motives

Henry Murray [Mry38] postulated the existence of 20 basic human needs as social motives. After him, other authors [MCR49] have highlighted three of these motives: *achievement*, *affiliation* and *power*.

Achievement motive is related to someone's needs of achieving *"success in competition with a standard of excellence"* [Rev92] specially in challenging tasks. High needs achievers used to perform better and persist longer in a moderated difficulty and challenges tasks than low needs achievers. *Affiliative* motive makes an individual develop new and maintain current interpersonal networks. Fear and anxiety can increase affiliative behavior and embarrassment can decrease. *Power* motive is characterized by the need to control or influence another person or group. These features make them seek for leadership and influential occupations. There are other kinds of motives considered by Clinical Psychology currents but they are beyond of the scope of this present work.

2.7 Conclusions

This chapter has made a summary of the main theory about cognition, emotion and motivation based on Cognitive Psychology approaches. Starting from the idea of human beings as an information processor, it has been shown how information gets organized in several levels of abstraction and complexity. Human beings are able to process *bottom-up* (sensorial information - inputs) and *top-down* information (motor actions, nervous actions and biochemical adaptive information), and at psychological level, *mental representations*.

Mental processing has, at least, two levels: one related to bodily, instinctive processes and conditioned responses (*automatic level of processing (ALP)*), and another related to the selective attention and *Working memory* (*controlled level of processing (CLP)*). The latter is elaborative and only processes some pieces of the whole information.

The organization of information at psychological level makes appear structures of knowledge (psychological constructs) also called *mental representation*. These structures work as mediator elements between the environment and the individual. It can be emphasized as examples of such structure the *semantic memory*, *procedural memory*, and *episodic memory* (Tulving model [Tul85]). The first is related to the organization of the knowledge about the world by means of linguistic codes. The second is related to the knowledge about "*how*" and "*when*" to act. And the last is related to recalls about experiences in someone's life. It also can be emphasized other mental representations defined by Power and Dalgleish [PwD97] that are: *model of the self*, *model of others*, *model of the world*, and *goal* representation. These structures of knowledge present a broad level of generalization aggregating many kinds of information. Also they are not isolated but they are very interweaved and there are not precise boundaries among them.

Emotion and motivation take place in structures of knowledge as part of the whole information; particularly information responsible for the procedures of body adaptations (sensations, hormonal levels, energy for action, etc.). The processing and the generation of emotion and motivation are complex and integrate several cognitive structures. Processing puts personal goals, plans, expectancies, beliefs, personality traits, personal motives, and physiological needs together to find the meaning of the current experience. Meaning is deciphered according to prior experiences and the most adequate procedure for the bodily and behavioral adaptation is triggered.

Many cognitive models of emotion and motivation were presented as sequentially organized. Bower's model [Bwr81] assumed the idea of semantic net suggesting a more parallel fashion of propagation of the information. But his theory is still limited to linguistic expressions. The SPAARS model proposed by Power and Dalgleish [PwD97] shows a parallelism but in a high degree of generalization. Also they suggested that PDP approach seems to be closer to the psychological low-level automatic processes. According to them, new models based on PDP approach need to be developed to achieve an adequate theory of cognitive processes.

Therefore, in spite of the several theories of cognitive, emotional and motivational processing, new ones have to be developed and tested yet. Models that incorporate parallelism and concurrence among information, new ways of dealing with imprecise information and structures of knowledge in several levels of complexity could be a great contribution to figure out such model. The current psychological approaches use Statistics and some ideas of Artificial Intelligence to have more objectiveness in their analysis. Possibly artificial tools as Neural Networks and Fuzzy Logic would be a big deal to model parallelism and imprecision of the psychological systems.

Chapter 3

ARTIFICIAL MODELING OF EMOTION AND MOTIVATION

3.1 Introduction

In the last years the AI area has been researching on how to include emotions in its models of intelligence. The idea of models of intelligence without considering emotion has been proved incomplete mainly after Damásio's [Dms94] and Goleman's [Gol95] works. Both considered emotional mechanisms as a fundamental part of the process of adaptation, which includes social adjustment, self-preservation, and decision-making capacity. So, AI has been looking for integrating emotion as part of the whole intelligence.

The emotional mechanisms in human beings and other animals resulted from millions of years of evolutionary process. Consequently, improvements occurred in the process of adaptation to the environment. Rational reasoning appeared more recently as a sophisticated mechanism of adaptation. Sometimes intelligence is defined as the capacity of adaptation. Thus, from this standpoint, to model intelligence in artificial systems it is necessary to take into account both mechanisms of adaptation: rational reasoning and emotion.

AI's challenge has been to find out feasible models of emotional process to make possible computational implementations. Neuroscience has shown, from a biological point of view, how complex and integrative this process is. Several areas of the nervous system (evolutionary older – limbic system - and newer – neocortex) can be driven in an emotional episode. Therefore, Neuroscience sees parallelism and concurrence among processes as an important characteristic of emotion.

On the other hand, Psychology has introduced several theories to explain this process and for this reason there is not just one model. Some of these theories have been presented in Chapter 2. These theories are incomplete and do not explain with enough accuracy the emotional phenomena. Consequently, AI should test these theories to propose models that are more adequate to a specific application or to help Psychology to understand better the cognitive-emotional process.

This chapter shows some artificial approaches of emotional process. There are three main approaches: those aimed at producing intelligent and emotional robots, those that develop virtual worlds where software agents have some kind of emotional behavior, and others that do not belong to the previous ones. There are also other researches related to the development of agents or algorithms to simulate emotional responses, and others related to the recognition of facial expression of emotions and character animation. These approaches have taken one or more psychological theories to modeling artificial emotions. Next some of these AI approaches are presented.

3.2. Artificial Modeling of Emotion and Motivation - Related Studies

Several approaches to model intelligent systems that consider emotion as part of intelligence have been studied. Some of those are concerned with facial expressions of emotions, which are mainly based on Paul Ekman's research [Ekm73] [Ekm94]. Ekman studied the common characteristics of facial expressions in many cultures. Based on these studies, computer graphics animation (e.g. [Hfk98] [DdW97] [CmF96] [ABC96] [KsO98] [TFM97]) and pattern recognizing (e.g. [EiP97] [KsY97]) are used to produce or to identify facial expression of emotions. These approaches will not be analyzed here because they are not part of the main purpose of this present work. Only those approaches, which are related to artificial models to generate emotional states, are going to be reviewed here. Among these, some are interested in embodying emotions in models of decision-making and adaptive intelligence in robots behavior (e.g. [EmS98] [SII96] [Vjd98]), some simulate emotion and motivation in artificial agents in a virtual world using computer graphics (e.g. [Cnm97] [CaF98] [PlT96] [UHH98]) and others are theoretical or related to some specific issue. They were grouped in three categories: robots with emotion and/or motivation, virtual environments, and other works.

3.2.1 Robot with Emotion and/or Motivation

There have been several researches using AI tools to model emotions. Velásquez et al. [VjM97][Vjd98][Vjd97] developed the Cathexis model influenced by Izard's system [Ice93] and Minsky's "proto-specialist" agents [Mkm86]. Each basic emotion is represented by different "proto-specialists" with monitoring sensors. Cathexis is a distributed model of generation of emotions where via a combination of different "proto-specialists" it is possible to simulate several aspects of the emotional process. It was implemented in a way that allows agent developers to create emotional autonomous agents.

Shibata et al. [SII96] developed an emotional robot to interact with humans. They have tried building a pet robot with artificial emotions. This artificial creature has a subjective appearance of "behaviors" that are dependent on internal states, or "emotions", as well as external stimuli from both the physical environment and human beings. According to psychologists *interaction* is important for the human mind and many of them agree that animals may help people to have great health benefits on mental and physical aspects on this process. Through interaction with human beings and/or the environment, the pet robot tries to behave in a way that is best for its survival. The pet robot has visual, auditory, and tactile sensors. The authors intended to create a robot that would be able to adapt to the environment through human-robot and robot to robot interaction learning through experience. They have implemented a neural network that learns how to integrate the various cues to produce correct localization on the horizontal plane, using visual cues, such as the motion of a person clapping his/her hands, such as a teacher, or training reference. They have studied the emergence of intelligence via non-verbal communication between humans and the pet robot through physical interaction.

Gomi et al. [GVI95] implemented versions of the Action Selection Dynamics (**ASD**) framework proposed by P. Maes[3] on a physical robot. The ASD mechanism determines which behavior should have the priority at any particular moment. The different behaviors are linked in a network representing the causal links between sensor inputs and behavior and between the behaviors. This network creates a process of spreading activation among all behaviors. Those behaviors in which activating energy is most concentrated will be given priority at a given time frame. The robot could learn the inter-behavior links through experience. The ASD network gets inputs from several different sensors (including vision), and supports learning to change inter-agent network relationships. Emotional states such as fear, curiosity, affection-seeking, hunger, joy, irritation, and anger are supported as emergent phenomena. The robot's on-board voice synthesis unit announces its internal states. Emotions provide a context within which the

[3] P. Maes – "*The Dynamics of Action Selection*" – Eleventh International Joint Conference on Artificial Intelligence, 1989 - cited in [GVI95]

robot will be able to continually re-evaluate its immediate goals. According to the authors robots equipped with emotions might perform better in real world, i.e. they simply might be better at achieving their tasks. Interruption of goal causes emotional disorder, which can be exploited in robotics to simplify or improve the robot's ability to carry out goal-oriented tasks.

Ulyanov and Yamafuji [UsY96] developed a biomechanical model to emulate a human riding a unicycle by a robot. The biomechanical model of a unicycle rider has an intelligent control system and a logical structure of distributed knowledge representation. In this structure the behavior and coordination level include *instinct*, *intuition* and *emotion* mechanisms. *Instinct* mechanism was realized as *local coordinator on fuzzy critic*; *intuition* mechanism was represented as *global coordinator* with random decision-making process on basis of genetic algorithm; *emotion* mechanism was described on the basis of sensor information of mechanical unicycle motion.

Mochida et al. [MIA95] proposed a behavior arbitration mechanism for autonomous mobile robots by modeling the artificial emotional mechanism. For them the conventional Artificial Intelligence technology (*sense-model-plan-act*) has many drawbacks under dynamically changing environments. On the other hand, in living organisms, there are mainly two systems (unconscious and/or conscious) to cope with dynamically changing environment: immune system, and emotional system. These systems serve as self-preservation systems. Based on that, they presented behavior arbitration mechanisms for autonomous mobile robots paying closer attention to the emotional system. To do so, they incorporated a model of the amygdaloid nucleus, which plays an important role in emotional activities, with genetic learning methodologies into an autonomous agent.

Hashimoto and Yamaguchi [HtY97] have produced and emotional agent that has sensors, recognition, emotional, awareness and behavioral nodes. They used an FCM – Fuzzy Cognitive Map – to construct the behavioral nodes of this agent. The agent approaches the person or goes away from him/her depending on the cause and effect model. The agent is a mobile robot whose recognition capabilities and behavior represents knowledge. Recognition is the assessment of a person's intentions and emotions using information that come from sensors. Emotions are represented by the status *like* or *dislike* a person, depending on the situation. Awareness is the behavioral intention of the agent. The main purpose of this research consisted of developing a system providing physical assistance to handicapped people by means of mobile robots (intelligent agents). These mobile robots get information via computer graphics that come from a CCD camera. A person can instruct an agent via gesticulation and the agent is able to estimate the person's intention ("go there", "go away from here") and the person's emotion ("happy" or "angry").

El-Nasr and Skubic [EmS98] investigated the use of emotional agents in the decision-making process of a mobile robot. They proposed a fuzzy logic model that captures the inherent uncertainty of emotions. Emotions have been shown to have a significant influence on the decision-making process of human beings and, thus, play an important role in intelligent behavior. El-Nasr and Skubic's model was used to generate decisions based on both internal and external states and incorporates the use of sensory information to extract environmental conditions. The agent is able to react to a changing environment and can take an action according to a mixture of emotions generated by multiple states. The model deals with three negative emotions: fear, pain and anger, chosen because of their instinctive structure.

3.2.2 Virtual Environments

Dickerson and Kosko [DjK93] suggested the use of Fuzzy Cognitive Maps (FCMs) to structure virtual worlds. They applied FCMs to an *undersea virtual world* where there are sharks, fishes and dolphins actors. The common causal concepts are survival threats and feeding. This results in threats to the fishes or the dolphins. The FCMs leads to chases, escapes, and other interactions between the actors. In this implementation FCMs can be used with different actors and even associated with Hebbian learning for pattern changes. This method can represent events, values, moods, trends, or goals as causal concepts and adaptation.

Cañamero [Cnm97] developed an experiment of a virtual autonomous creature situated in a two dimensional world that shows various learning and problem-solving capabilities, within the Society of Mind framework. This model is also based on Minsky's [Mkm86] ideas, which consider a general principle of intelligence as a emergence from the interactions of simple societies, non-intelligent agents "cleverly engineered". She approached emotional and motivational behavior from a developmental perspective using physiological and psychological parameters, which are seen in analogy with control systems. The creature is a newborn whose behavior is strongly driven by motivational states - impulses to action based on bodily needs - and basic emotions - peripheral and cognitive responses are triggered by the recognition of a significant event. Motivations drive behavioral selection and organization based on the notions of arousal and satiation, and the exploitation principle. Emotions exert further control by sending 'hormones' that may affect the intensity of the selected behavior, enable it, or prevent it. They also influence the attention and perception mechanisms.

Ushida, Hirayama and Nakajima [UHH98] developed an interesting emotional model using agents. They implemented a multi-module architecture based on Ortony's cognitive appraisal theory [OCC88]. Agents model emotional and cognitive processes interaction and learning mechanisms are used in order to diversify behavioral patterns. The life-like agents have emotions and motivations that are trigged by reactive and deliberative mechanisms. A multi-module architecture is employed in order to carry out the interactions. They applied the proposed model to three characters in a virtual world through computer graphics associated with a device with sensors. The users interact with this device to evoke emotions in virtual characters. The implementation consisted of using a multi-module architecture to carry out the emergence of behaviors through interactions between cognitive and emotional processes. Fuzzy inference mechanisms were applied to produce flexibility in behavior. Distinctive personalities were achieved by differences in expressing emotion. Tuning the rules and parameters in modules allows generating various different personalities.

Camurri and Ferrentino [CaF98] introduced a model of artificial emotions embedded in the architecture of emotional agents. These emotional agents have rational knowledge and reactive capabilities, and can interact with other agents and the external world including humans. The psychological idea based upon Frijda[4] and Johnson–Lard works with human emotions. Their model was applied in several multimedia-multimodal application environments. They tried interaction between the system and humans and became especially interested with the interaction with children.

Inoue and Kobayashi [IkK97] proposed a decision-making system derived from evolutionary process. This system acts as if it has emotion. Inoue and Kobayashi support the idea that emotion is the most reasonable decision-making system to maintain the individual and its species. They set a virtual environment in a computer, where some kinds of virtual animals live. The evolution of artificial life is generated by genetic algorithm and emotions come out as part of living instincts.

Padgham and Taylor [PlT96] developed agents in a virtual world that have characteristics of emotion, motivation and personality. They considered that emotions and personality interact with goal-oriented behaviors generating motivational states. In this model, emotions are seen as existing in pairs of opposites – pride and shame, happiness and sadness, love and hate. The effect of an emotion on the behavioral and cognitive subsystems of the agent comes into play when an emotion crosses the threshold for that agent. The implemented emotional model provides three different mechanisms, which can be used to model agent personality. These are the motivational concerns, the emotional threshold, and the rate of decay of an emotion. The combination of different degrees of those parameters generates different personalities. Motivational concerns are associated with states, which are recognized as threats (or opportunities), and with emotional

[4] Frijda, N.: *Emotions*. Bologna, Italy, 1986; cited in [CaF98]

reactions. Tests with this system, in spite of the simplicity of the emotional model, showed that it is possible to model agents whose differing personalities resulted in differing behaviors, given similar external situations.

3.2.3 Other Works

Elliot [Cle94], based mainly on the ideas of Ortony, Clore, and Collins [OCC88], described *research problems in the use of a shallow Artificial Intelligence model of personality and emotion*. He intended to expand the idea of emotion and personality, to analyze the feasibility of the emotional representation in the computer, and to build agents that are capable of emotional interaction with users. For that he used a large AI program called *Affective Reasoner*, which simulate simple virtual worlds. Agents, those that are able to have emotional responses, populate these worlds. Also, agents are given unique pseudo-personalities as a set of *appraisal frames* representing their personal goals, principles, preferences, and moods, and a set of *channels* for the expression of emotions. Combinations of these aspects are used to generate agent's interpretations of situations that unfold in the simulation. Elliot et al [EBS98] implemented semi-automatic *story-morphing* techniques based on the ideas of the *Affective Reasoner* project. They studied narratives based on real life, and analyzed those narratives using the *Affective Reasoner* paradigm. Then they created large numbers of similar, although different, plausible stories, which shared the same external, plot steps, but which contained widely varied emotional responses, on the part of the characters, to these external events. In theory, these stories can be generated automatically from a single narrative. This technique might be used to create storyteller agents, agents for education, computer fantasy games, and intelligent multi-participant computer games.

Webster [WbC98] approached adaptive depression as part of the whole intelligent condition in humans and computers. For him, intelligent systems have to detect patterns of failure in memory, retreat from dangerous environments, explain failures, rehearse new behaviors off-line, and return to new, quick, successful behavior - until their environment changes again. Computer models of adaptive depression are a kind of affective computing, because they can provide reasoning and emotion to artificial systems. Human adaptive depression allows people to save resources (e.g. energy) to cope with present difficulties in the environment, to improve assessment of long-term strategic prospects, and to regulate goals in human social hierarchies. Like humans, it is interesting that robots can decide if it is necessary to reduce power consumption and risk exposure, if they need more space or time to analyze their behaviors, and to regulate their interaction with each other (human or machine). These characteristics make possible for robots to better adapt their behavior when any adverse situation occur.

Sato and Morishima [SjM96] described the modeling scheme of emotions appearing in a speech production. For that they used a neural network and the synthesizing technique of emotional condition from neutral speech. They introduced the Emotion Space to model emotional conditions in speech production. Emotion Space can represent emotional condition appearing in speech production in a two dimensional space and realize both mapping and inverse mapping between the emotional condition and the speech production. They developed the Emotional Speech Synthesizer to synthesize emotional speech. The Emotional Speech Synthesizer has an ability to synthesize an emotional speech by modifying a neutral speech in its timing, pitch and intensity.

Sloman et al. [Slm97][Slm98][SaL98] approached several factors (such as beliefs, desires, intentions, mood, emotion among others) that need to be considered in order to implement an appropriate layered architecture that intends to model the human mind. They conjectured that these layers should be at least three: reactive, deliberative and meta-management. Also, they suggested that many architectures are needed because humans differ from one another and different architectures support different classes of mental states. They designed a system called SIM_AGENT toolkit[5], which has been used to explore a variety of such architectures.

Botelho and Coelho [BlC98] developed architecture for autonomous agents that display the same kind of regulation capacities provided by emotion. They distinguish cognitive from affective appraisal, on an architecture-grounded basis. Cognitive appraisals are performed by the cognitive components of the architecture (cognitive engine). Affective appraisals are performed by affective components (affective engine). These two engines can be distinguished in terms of the type of information processed, the purpose of information processing, and the typical processing time. The Salt & Pepper program is the implementation of that architecture where autonomous agents display the same kind of regulation capabilities provided by emotion. It has three major independent blocks that run in parallel with each other: the Cognitive engine, the Affective Engine, and the Interrupt Manager. There is also a *Long-term memory* that is an associative network with spreading activation. Emotional-responses are contained in nodes stored and interconnected in *Long-term memory*.

[5] For more information see http://www.cs.bham.ac.uk/~axs/cogaff.html

Ventura and Pinto-Ferreira [VPf98] also developed an emotion-based agents system. They used two different standpoints: a *cognitive*, and *perceptual immediate*. The first is elaborative and allows agents to understand what is going on and what they know about the world. And the second enables the agents to react quickly and decide adequately in situations requiring urgent action. Hence, from the same complex stimulus, two sets of facets are extracted: one, mostly directed to recognition and reasoning purposes, and another, aiming at assigning degrees of threat, danger, pleasure, and so on, to the current circumstances, constructing a *vector of desirability*. When an unknown object appears in the scene, its perceptual image is extracted and a first estimate of the vector of desirability, as well as the corresponding decision-making in the short-term is performed. If the agent does not find a match in the memory, a new perceptual association is established

3.3 Conclusions

In spite of several works that have been developed to achieve ways to artificially model emotion, motivation, and personality, there are a lot of aspects that need to be researched yet. Psychological models have to be explored through simulation trying to accomplish a general theory. In addition to artificial models, new theoretical approaches might be developed enriching traditional methods of Psychology to deal with concepts/information. Psychology often used Statistics and other mathematical techniques to make this area a little more objective. Thus, AI could contribute so much to improve models of cognition and emotion through techniques such as Neural Network, Fuzzy Logic, Genetic Algorithm, and so on. Many aspects of the psychological reality as for example concurrence, inexactness, and many combinations of information could be modeled closer to what they are in fact. In the next chapters a new approach to these issues, aiming at finding a different standpoint to analyze this matter, will be suggested.

Chapter 4

FUZZY COGNITIVE MAPS TO MODEL COGNITION, EMOTION, AND MOTIVATION

4.1 Introduction

This chapter discusses Fuzzy Cognitive Maps - FCMs. Kosko [Ksk86] created this tool, which it has become a very good way to represent some ill-defined complex systems. It has features that combine some aspects of Neural Networks and Fuzzy Logic. It makes possible to add parallelism (concurrence of information), vague characteristics, and the chance of combining different FCMs to get an augmented FCM. These features of this tool are very interesting to model psychological processes.

The first parts of this chapter describe FCMs from a mathematic point of view. An example is shown along with some advanced applications. Some authors have been using FCMs associated with other techniques such as Rule-based Systems and Genetic Algorithms. Also some changes in the original technique have been proposed.

In order to construct an FCM it is necessary to gather information about the matter to be approached. It can be done through interviews or questionnaires applied to experts, through written information in specialized documents, through asking experts to draw an FCM, and through a discussion meeting among experts. After that a knowledge engineer has to manage the information to define an appropriate FCM for that subject.

The last part of this chapter describes the potentiality of using cognitive maps in the modeling of emotional and motivational processes. The psychological models proposed to model emotional and motivational processes have some constraints. Frequently, they present these processes as sequential not showing the concurrence and parallelism of information. FCMs are able to model the cognitive emotional and motivational processes as a complex system that operates in a parallel manner. Also the nodes of that FCM stand for a Fuzzy Set that can have several subsets. Each subset represents some kind of information or some pattern of combination among information. The weighted edges that connect the nodes represent the *degree of subsethood* among them, that is, their intersection.

4.2 What Are Cognitive Maps?

According to Axelrod [Axe76] a cognitive map is a specific way of representing a person's statements about some limited domain. It allows to take the makeup out of a person's causal assertions and to predict the consequences that follow from this structure of ideas.

A cognitive map can be regarded as a complex system that mathematically models a person's belief system. In this complex system "the whole is more than the sum of the parts". Translating to "a pragmatic sense it means that given the properties of the parts and the laws of their interaction, it is not a trivial matter to infer the properties of the whole."(Herbert Simon 1969, p. 86 in Axelrod pag 55 [Axe76]).

Cognitive maps can be seen of as a particular type of complex system with two parts – nodes and edges - and two basic laws of interaction among the parts – cause or non-cause. Then, once the properties of parts and the laws of their interaction are known, inferences can be made about the properties of the whole cognitive map. Based on someone's cognitive map, Axelrod intended to address questions such as: How would a person make choice among alternatives? Would it be possible to make predictions about future attitudes? How a change in one concept influences the other ones? and so on. In other words, how a person's decision-making process works.

4.3 What Are Fuzzy Cognitive Maps (FCMs)?

Bart Kosko [Ksk86] combined Axelrod ideas about Cognitive Maps and Fuzzy Logic creating the Fuzzy Cognitive Maps - FCMs. Fuzzy cognitive maps (FCMs) are fuzzy-graph frameworks to represent causal reasoning. These kinds of graphs are directed graphs or *digraphs* because each edge is assigned an orientation [BnL96]. Systematic causal propagation, in particular forward and backward chaining, can be analyzed by means of a mathematical treatment of these digraphs through Fuzzy Causal Algebra. Causality is represented as a fuzzy relation on fuzzy causal concepts. FCMs nodes represent variable phenomena or fuzzy sets.

There are some similarities between FCMs and Neural Networks [Ksk87]. Carvalho and Tomé [JcJ99], and Stylios and Groumpos [ScG00] have considered FCMs as a combination and synergism of neural networks and fuzzy logic that allows the prediction of the entailments of changing the concepts that are represented in causal maps. For Carvalho and Tomé [CjT99], FCMs are actually man-trained neural networks. For them, the main success of this technique resides in the fact that they provide an easy and fast method to create and simulate qualitative dynamic systems with feedback that try to mimic human reasoning. In addition, FCMs allow knowledge bases to be grown by connecting different FCMs working as a single knowledge network.

Figure 4.1 shows a generic FCM with generic concepts (C1, C2, C3,…Cm e Cn) and weighted edges (arrows) among them (w_{12}, w_{21}, ……w_{mn}, w_{nm}). Each concept represents a fuzzy set or a fuzzy variable, and the edges represent a fuzzy causal relation between the concepts. This kind of relation usually represents three possibilities: no causal relationship (no link between concepts), positive causal fuzzy relationship, or negative causal fuzzy relationship. This illustrative graph can be translated as a matrix where each element corresponds to a value of the edges among the concepts. Figure 4.2 shows this matrix $\mathbf{W}_{\mathbf{nxn}}$.

A weighted edge w_{ij} from causal concepts C_i to C_j measures how much C_i causes C_j. Usually the edges w_{ij} can take some value in fuzzy interval [-1,1]. Value of the edges $w_{ij} = 0$ represent no causality between a C_i and C_j concepts. If C_i increases and causes the increase of Cj then w_{ij} is greater than zero. If C_i decreases and causes the decrease of C_j then w_{ij} is also greater than zero. If C_i increases and causes the decrease of Cj then w_{ij} is less than zero. If C_i decreases and causes the increase of C_j then w_{ij} is also less than zero. Therefore:

$$\text{If } \boldsymbol{C_i} \uparrow \Rightarrow \boldsymbol{C_j} \uparrow \text{or } \boldsymbol{C_i} \downarrow \Rightarrow \boldsymbol{C_j} \downarrow \text{ then } \boldsymbol{w_{ij}} > \mathbf{0} \tag{4.1}$$

And

$$\text{If } \boldsymbol{C_i}\uparrow \Rightarrow \boldsymbol{C_j}\downarrow \text{ or } \boldsymbol{C_i}\downarrow \Rightarrow \boldsymbol{C_j}\uparrow \text{ then } \boldsymbol{w_{ij}} < \mathbf{0} \tag{4.2}$$

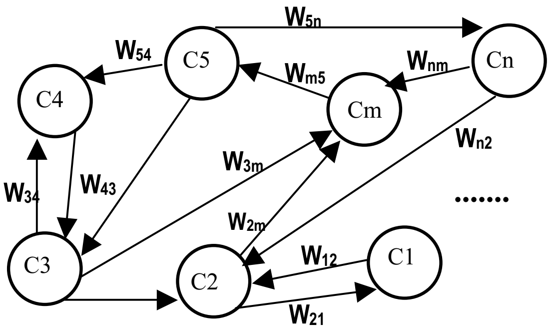


Figure 4.1- Generic example of Fuzzy Cognitive Map.
$C_1C_2 \dots C_mC_n$ = concepts; W_{ij}= weighted links (causal relations). (Adapted from Stylios and Groumpos [ScG00]).

		E F E C T ⇓						
		C1	**C2**	***C3***	***C4***	**...**	***Cm***	***Cn***
	C1	w_{11}	w_{12}	w_{13}	w_{14}	...	w_{1m}	w_{1n}
C	***C2***	w_{21}	w_{22}	w_{23}	w_{24}	...	w_{2m}	w_{2n}
A	***C3***	w_{31}	w_{32}	w_{33}	w_{34}	...	w_{3m}	w_{3n}
U	***C4***	w_{41}	w_{42}	w_{43}	w_{44}	...	w_{4m}	w_{4n}
S	...	...	...	...	...	...	...	...
E	***Cm***	w_{m1}	w_{m2}	w_{m3}	w_{m4}	...	w_{mm}	w_{mn}
⇒	***Cn***	w_{n1}	w_{n2}	w_{n3}	w_{n4}	...	w_{nm}	w_{nn}

C1= concept 1
C2=concept 2
C3=concept 3
C4=concept 4
...
Cm=concept m
Cn= concept n

Figure 4.2-Representative matrix of the FCM shown in the Figure 4.1.

The calculation in FCMs consists of a multiplication of a vector $\mathbf{C^{t}_{1xn}}$ to a matrix $\mathbf{W_{nxn}}$. The vector $\mathbf{C^{t}_{1xn}}$ represents the fuzzy concepts in a time ***t***, and it is the input information. The matrix $\mathbf{W_{nxn}}$ represents the fuzzy weighted edges (the causal relation among the concepts). As a result, vector $\mathbf{C'^{t}_{1xn}}$ is obtained. Vector $\mathbf{C'^{t}_{1xn}}$ is taken as the input to a *threshold function*. The *threshold function* restrains the vector values within a limited rank. Consequently, quantitative results are avoided and to compare nodes status becomes easier. It can also be associated with the vector $\mathbf{C}_{1\,\mathrm{xn}}^{t=0}$ generating another vector $\mathbf{C}_{1\,\mathrm{xn}}^{t+1}$ ("clamped" a specific node as active). This last vector will become the new input. Then the process of multiplication will be repeated until the finding of FCM resonant states. *Resonant states* or *hidden pattern* are obtained when $\mathbf{C'}_{1\,\mathrm{xn}}^{t}$ is repeatedly equal to $\mathbf{C'}_{1\,\mathrm{xn}}^{t+1}$ or some set of $\mathbf{C'}_{1\,\mathrm{xn}}^{t}$ are repeated successively. An FCM *limit cycle* or *hidden pattern* is an FCM inference. The value of each concept is calculated regarding the influence of the interconnected net [ScG00], so:

$$\mathrm{C}_{1\,\mathrm{xn}}^{t+1} = f\left(\mathrm{C}_{1\,\mathrm{xn}}^{t} \times \mathrm{W}_{n\times n}\right) \qquad (4.3)$$

A *threshold function* f gives as output a value for concept C_i in the fuzzy interval [-1, +1], where the N concepts of FCM take values. Threshold functions can be defined to fit the particularities of each project. For example, Mohr [Mst97] in his project tries out three threshold functions: *bivalent*, *trivalent* and *sigmoid function* (logistic signal) as shown in Equation 3, 4 and 5. But other threshold function might be chosen according to the specificities of each project.

The threshold function provides a fashion to constrain unbounded inputs to restrict range. Thus the possibility of quantitative results tends to disappear only giving base to compare nodes – on or off, active or inactive. These mappings offer a qualitative model without a precise quantification of the weighted edges, which is required in a Fuzzy System. [Mst97].

$$\left.\begin{array}{l} f_i(x_i) = 0, x_i \le 0 \\ f_i(x_i) = 1, x_i > 0 \end{array}\right\} \textit{bivalent} \qquad (4.4)$$

$$\left.\begin{array}{l} f_i(x_i) = -1, x_i \le -0.5 \\ f_i(x_i) = 0, -0.5 < x_i < 0.5 \\ f_i(x_i) = 1, x_i \ge 0.5 \end{array}\right\} \textit{trivalent} \qquad (4.5)$$

$$\left. f_i(x_i) = \frac{1}{1 + e^{-\lambda x_i}} \right\} \textit{sigmoid function} \qquad (4.6)$$

4.4 Gathering Information to Construct Fuzzy Cognitive Maps

According to Kosko [Ksk91] a simple FCM provides a quick first approximation to an expert's assertion or printed causal knowledge. An expert can easily draw causal pictures of his/her problem or respond to questionnaires. This picture or questionnaire will express his/her structure of beliefs about that theme, his/her biases, prejudice, wisdom, knowledge or ignorance. Knowledge engineers can similarly transcribe interviews or printed documents. Combination of FCMs is also possible by means of data association of iterative interviews or questionnaire mailings. Moreover, it is feasible to add two or more FCMs to produce a new FCM.

When different experts are consulted they can differ on how they assign causal weighted edges and on which concepts they believe causally relevant**.** They may agree or disagree with the local causal arrangement and perhaps the global balance. Then the knowledge engineer can add FCMs providing a partial solution to this problem. In that superposition, each expert's FCM is combined and conflicting opinions would have a tendency to cancel out and then a consensus emerges.

Taber and Siegel [TwS87] assumed that the concurrence of an expert with others implies a higher level of expertise. These authors also provided a mechanism to assess the credibility of an individual map. For them, some experts can have more credibility than others. So each expert has his/her map associated with a different weight according to his/her credibility. A knowledge engineer might assign the degree of credibility of each expert according to some previously chosen criterion.

4.5 **An Illustrative Example**

Stephen Mohr [Mst97] developed an example that is shown below. He tried to model property theft in a community. He chose the following concepts:

- ***C1*** = *Opportunity* – physical access to property, availability of burglary tools, etc.
- ***C2*** = *Community involvement* – town watch, communication between neighbors, crime reports in local news
- ***C3*** = *Police presence* – the visible presence of uniformed officers on a regular basis
- ***C4*** = *Punishment* – a measure of the reliability and certainty of punishment for crimes
- ***C5*** = *Criminal intent* – the presence of persons intending to commit theft
- ***C6*** = *Presence of property* – the visible presence of goods desired by thieves
- ***C7*** = *Theft* – actual taking of property

For those concepts he proposed the Fuzzy Cognitive Map illustrated in Figure 4.3. This figure represents the following statements:

- Presence of property increases criminal intent, theft, and opportunity
- Police presence decreases theft
- Punishment decreases criminal intent
- Theft decreases opportunity

Figure 4.4 represents the matrix $\mathbf{W}_{7x7}$ that corresponds to the FCM shown in Figure 4.3.

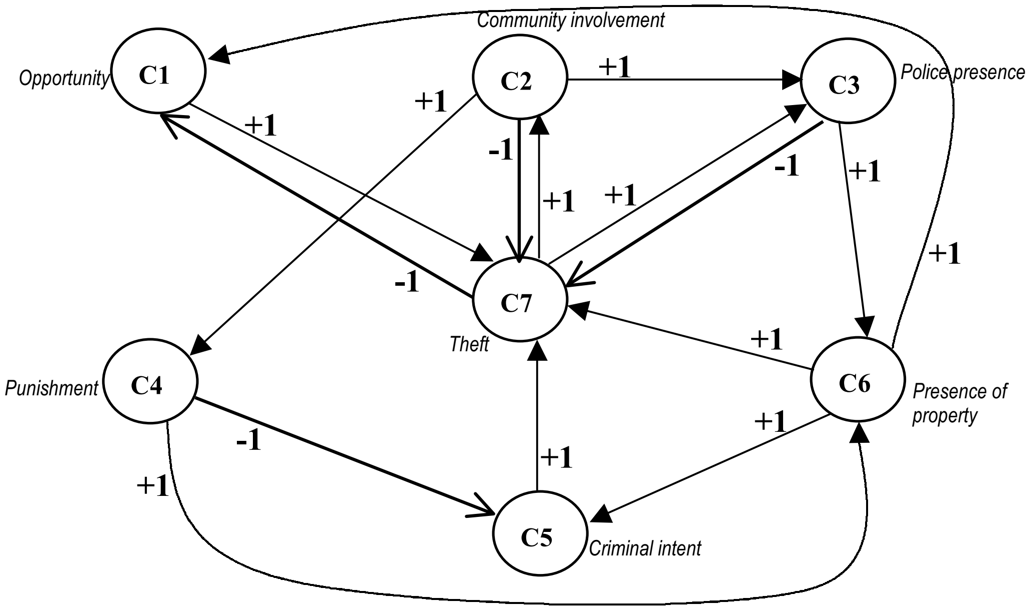


Figure 4.3- Crime and punishment FCM (adapted from [Mst97]).

		E F E C T ⇓						
		C1	**C2**	*C3*	*C4*	*C5*	*C6*	*C7*
	C1	0	0	0	0	0	0	+1
C	*C2*	0	0	+1	+1	0	0	-1
A	*C3*	0	0	0	0	0	+1	-1
U	*C4*	0	0	0	0	-1	+1	0
S	*C5*	0	0	0	0	0	0	+1
E	*C6*	1	0	0	0	+1	0	+1
⇒	*C7*	-1	+1	+1	0	0	0	0

C1= Opportunity
C2= Community involvement
C3= Police presence
C4= Punishment
C5= Criminal intent
C6= Presence of property
C7= Theft

Figure 4.4 - Crime and punishment weighted edges connection matrix.

Mohr tried to activate the concepts C3 – *Police presence* – and C6 – *Presence of property* as an input vector. Therefore the starting state vector is:

$$\mathbf{C_0} = \begin{pmatrix} 0 & 0 & 1 & 0 & 0 & 1 & 0 \end{pmatrix}$$

He took the FCM above and the starting vector C_0 and observed what happened to the simulation under three threshold functions (bivalent, trivalent, and sigmoid). He analyzed the results for each case considering the limit cycle and consistency of the data obtained. The interpretation of that data is not of the purpose of this present work, for more details see Stephen Mohr [Mst97].

4.6 Advances in FCMs Applications

FCMs have been used for many applications, sometimes alone and some other times combined with other techniques. FCMs combined with other artificial intelligence techniques promote a synergy between advanced technologies such as Neural Network, Genetic Algorithms, Fuzzy Logic and Probabilistic Reasoning. Stylios and Groumpos [ScG00] called this combination *soft computing*. For instance, FCMs were applied in geographic information systems [Jns00][ZqS99][SZq99][SrZ99], in distributed systems [SGG97], in psychological and social models [HtY97][CpC94], in decision-making studies [PkM97][Zwr94], associated with genetic algorithm [EDS00], among others.

Ndousse [Ntd96] showed how FCMs could be used to model fault propagation in networks. As an expert system, the computational capability of FCMs makes them an alternative to the Rule-based Systems. These are considered much slow for real time applications. As FCMs can be easily automated Ndousse integrated them into network management software.

Stylios, Georgopoulos and Groumpos [SGG97] used FCMs in modeling behavior of distributed systems. They divided the whole plant in virtual parts and constructed for each part an FCM. Each part can use the experience of different specialists who can easily judge the variables and states of a small process creating an FCM. Then the FCM of each expert can be united to others to construct a final system by integrating the different FCMs into an augmented one. This approach represents systems in a graphical way showing the causal relationships between states-concepts and accomplishes the unification of knowledge by superposing small systems. It offers the opportunity to produce better knowledge based on system applications, addressing the need to handle uncertainties and inaccuracies associated with real world problems. According to these authors, this method can increase the effectiveness, autonomy and intelligence of systems.

Carvalho and Tomé [CjT99] have considered FCMs as a combination of Neural Networks and Fuzzy Logic that allows predicting the change of the concepts represented in causal maps. For them FCMs are indeed man-trained neural networks. FCMs main success resides in the fact that they provide an easy and fast method to create and simulate qualitative dynamic systems with feedback. The authors have suggested the use FCMs associated with Rule-based Systems. They called such association RBFCM (Rule-Based Fuzzy Cognitive Map) that uses linguistic fuzzy rules to describe relations among concepts. RBFCM can represent flexible causal relations and other kinds of relations.

In an usual approach, it is assumed that FCMs concepts are not able to influence themselves, which means no cause and effect relationship between a concept and itself. In this fashion the weight w_{ii} is zero, that is, diagonal elements are all zero. However, Stylios et al. [ScG00] have shown the possibility of *Self-feed FCMs*. They have assumed the possibility of the diagonal elements not being zero ($w_{ii} \neq 0$). For them *Self-feed FCMs* have many advantages. Using the past value of each concept in the calculation of a new value, a system has a memory of one step. Sometimes this effect would make possible to reach the *limit cycle* (region of convergence) faster than the classical method.

There are other applications with FCMs, which have been developed since Kosko's first publication [Ksk86] until now but for the purpose of this work only these last ones have been presented.

4.7 Potentiality of Using FCMs in Modeling of Emotion and Motivation

In Chapter 2 several cognitive approaches of the emotional and motivational processes were shown. In spite of these various models, the cognitive-emotional-motivational processes are not enough explained yet. Such processes are multifaceted what allows seeing them from different points of view.

Power and Dalgleish [PwD97] have remarked that PDP (Parallel Distributed Process) approach would be the best framework to simulate the low-level automatic processes that take place in the brain. But they believe that theory needs to be modified in order to find out an adequate model for emotional processes. Therefore, these authors point to the necessity of new conceptions based on PDP assumptions.

PDP approach models the low level of biological operation of the nervous system, that is, it simulates how the neurons and synapses work to store and to learn information. The Neural Networks (PDP approach) have had a very good performance in pattern recognition. This kind of operation is equivalent to the level of sensorial (analogical) information. Taking a look at the SPAARS model (Figure 2.2), the PDP approach could simulate the *analogical level* and part of the *associative level* of interpretation of the event. Schematic and Propositional levels correspond to large and complex structures of knowledge that represent abstracts meanings and high levels of generalization of information. Simulation of these levels by conventional Neural Networks would imply in a huge and complicated net, which would probably have many constraints in relation to representation of the human brain and technological difficulties for implementation.

A possible solution for that question could be to model cognitive-emotional-motivational process by means of FCMs. FCMs have some features that work as a Neural Network, in terms of parallelism and concurrence among information. However the FCMs' nodes stand for concepts, which are able to describe simple neurons or complex ideas about some issue. FCMs nodes represent concepts (ideas) that could be related to larger structures of knowledge (mental representations) with some degree of complexity. Such structures would correspond to a specialized Neural Network, which has stored a pattern of information. Therefore an FCM would model the interconnection of several Neural Networks (represented by concepts) increasing the level of abstraction and generalization of the information. Such FCM would be a similar framework to a common Neural

Network but working in a level above the analogical and associative level (*low-level automatic processes*).

In addition, each concept (node) in an FCM stands for a Fuzzy Set. This fact is very meaningful because the structures of knowledge represented by concepts are indeed vague and show a great quantity of common information with other ones. Fuzzy Logic also allows operation with sets such as *union* and *intersection*, which are very useful for the understanding of interconnection among mental structures.

According to the last ideas FCMs seem to be a powerful tool to represent mental reality. FCMs put the advantages of Fuzzy Logic and Neural Network together allowing the simulation of inaccuracy of information and parallelism in high-level structures of knowledge. So, it becomes easier and more practical to use FCMs to simulate high-level mental processes than common Neural Networks. Cognitive-emotional-motivational processes work together in several levels of complexity of information organization. Thus, to simulate such processes by means of FCMs appears to be a good idea that has not been tested yet. In Chapter 5 this concept is further detailed.

4.8. Conclusion

This chapter has explained Fuzzy Cognitive Maps – FCMs -, their usefulness, applications and possibilities. Bart Kosko associated the Cognitive Maps proposed by Axelrod with Fuzzy Logic creating FCMs. This tool is an easy and quick way of describing a complex system. FCMs put a great part of Neural Network and Fuzzy Logic advantages together. Due to this characteristic it becomes powerful to model mental representations.

Especially in the case of the cognitive-emotional-motivational processes, which bind together a lot of information (representations) that interact one to another. FCMs seem to be the means that fit the entire characteristic of this process: highly parallel and not precise. The proposal of the present work is to try out the use of FCMs to model cognition, emotion, and motivation as a fuzzy complex parallel system.

Chapter 5

AN APPROACH OF COGNITION, EMOTION, AND MOTIVATION THROUGH FUZZY COGNITIVE MAPS

5.1 Introduction

This chapter describes the main ideas proposed by this research. A new fashion of approaching emotion, motivation and personality traits by means of Fuzzy Cognitive Maps - FCMs will be defined in the following sections.

It will be assumed that emotion, motivation, personality traits, and cognition are facets of the same matter, that is, the mental processing of information. Several analyses of such processing are possible depending on the point of view and/or kinds of information that someone might consider. The term cognitive will be used in a broad sense including all information or structures of knowledge (emotional, motivational, semantic, sensorial, etc.) that can be present in someone's mind.

Cognitive aspects of information processing and knowledge organization will be modeled based on the assumptions of parallelism and integration of information. Mental representations will be taken as structures of knowledge, which can put sensorial information, and very complex and abstract organization of information together. Among these more complex structures of knowledge, the following ones will also be taken into account: *semantic memory*, *episodic memory*, and *procedural memory,* respectively, according to Tulving's model, and *goal* representations, *model of the self*, *model of others*, and *model of the world* according to Power and Dalgleish's ideas.

Those complex structures of knowledge are very comprehensive thus some of their instances will be defined. Such instances will be generically called *Concept*s, which will be the nodes of an FCM. These *Concept*s will describe some aspects of emotion, motivation, personality traits, goals, self, etc. These *Concept*s form small net identified by means of words or linguistic expression, and aggregating several kinds of information. The weighted edges among the concepts will be defined by a research to gather the opinion of some psychologist (experts). Then the *Concept*s and the data collected will be put together to outline an FCM. Such FCM will be analyzed to assess its potential of representation of mind reality.

FCMs have a great potential of modeling mental reality due to their characteristics of simulating concurrence among information and representation of knowledge structures, as well as the possibility of combination with other FCMs. An FCM allows working with nodes or concepts as Fuzzy Sets, which can represent complex structures of knowledge, in addition to many desirable features of Neural Networks.

5.2 Mental Representations as Fuzzy Sets

The objective of this section is to demonstrate how it is possible to model a mental representation as a Fuzzy set and the advantages of such approach. Firstly, relevant aspects of mental representations are explained. Especially verbal representations are detailed due to their potential of standing for meanings in high levels of abstraction and generalization, as well as of establishing a large net of connection among information. Secondly, how a verbal code defines a *Concept*, and how a *Concept* can be modeled as a Fuzzy set.

5.2.1. Mental Representations

In Chapter 2 it was assumed that human adaptation to the environment is mediated by his/her mental representations. Mental representations are psychological constructs that bind together, in an idiosyncratic fashion, all kinds of information that an individual is able to deal with (kinesthetic, visual, auditory, and linguistic information). Part of these constructs is related to bodily adaptation and the direction of behavior. Emotion and motivation are psychological aspects mainly related to these last ones.

Some approaches of memory are more related to processing of information, e.g. Atkison-Shiffrin model [AkS68], Level of Processing approach [CkL72], and PDP (*Parallel Distributed Processing*) approach [McR86]) and others are more related to knowledge and its representation (e.g., Tulving model [Tul85] - see Chapter 2). Tulving's model of memory – *semantic*, *procedural*, and *episodic* memories - indeed represents organization of knowledge. Based on the PDP approach it is assumed that these three structures are not separated but very interweaved with each other. Thus, it could be considered that when some kind of information is activated in someone's mind some other kind of related information can be easily activated. For example, if someone is looking at a picture of a dog, semantic relations might be retrieved (spontaneously or by means of verbal induction of another person) such as categories of dogs or others mammals, recalls of lived experiences with dogs as a friend or as a threat, or recalls about how to act with this kind of animal (for instance petting, running away, not caring about). Then the flow of thoughts is able to trigger information or knowledge directly or indirectly associated with the idea "dog". These recalls can be mental images that aggregate visual and/or auditory, and/or olfactory, and/or taste, and/or kinesthetic, and/or verbal information according to someone's prior knowledge of that situation.

These recalls work as a mental "navigation". The method of *free association* that is applied in Psychology through free verbal explanation is a similar process. In Psychoanalysis the chain of associations that were activated reveals the patient's mental history and present organization of his/her mind [PEw96]. Free association is also applied to the study of the prevailed semantic relations that a subject often uses. In this last case that method can aid diagnosis of some pathological states of the brain [Lra91]. Besides these two approaches, hypnosis employs verbal language to establish multi-level communication [OjS96] [Rss93] in therapeutic processes trying to figure out the causes of traumas or other psychological disturbances. During this process mental images are driven to a conscious level and then analyzed in their deep meaning.

Power and Dalgleish [PwD97] proposed a division of mental representation in three formats: *analogical* (sensorial modalities); *propositional* (abstract representations of ideas that can be expressed in natural language); and *schematic* (higher-level structures of knowledge). These formats represent levels of abstraction of the mental representation and they are also related to knowledge organization as in Tulving's model. For these authors the *schematic level* represents *domains of knowledge* in an individual's mind about *model of the self*, *model of other*, *model of the world* and representation of *goals*. These complex representations cannot be easily expressed in natural language. By means of analyzing of SPAARS model (see Figure 2.2) it can be inferred that the sensorial information that arrives in someone's mind is firstly identified in the *analogical level* and then it can drive in a parallel way the other levels of organization of knowledge. Thus the levels of processing interact with each other promoting a *massive parallel operation*. This processing is carried out in order to find some matching pattern of in all the levels of knowledge organization. Sensorial patterns would be analyzed mainly in the *associative level*; linguistic contents or abstract ideas would be analyzed by *Propositional level* (level of ideational meaning) and *Schematic level* (deeper meaning).

Therefore, it can be concluded that mental representations are facets of knowledge organizations and mental information processing. They can be analyzed from different points of view depending on which pattern of organization/processing someone is looking at. These structures of knowledge organization are packages of information (sensorial and linguistic information) that are interweaved and can interact with each other. So, this way of conceiving mental representations agrees especially with the PDP model of processing and the SPAARS model. In addition, it is necessary to consider that by means of the verbal language a chain of associations connecting representations can be driven or even created generating mental processing in a surface level or in a deep level [Chk57]. Verbal language is a powerful code, which can easily represent and activate other kind of representations or can establish relations between them. The main characteristics of the verbal code are to enable abstraction and generalization about sensorial information. Abstraction and generalization can be used by humans to establish higher levels of complexity in the structuring of information that allow more sophisticated uses of mechanisms of thought and reasoning. Thus, in the next section will discuss linguistic code and semantic structures as mechanism of abstraction and generalization, and also their potentially of representing any kind of information.

5.2.2 Linguistic Code and Semantic Structures

According to Luria [Lra91] the verbal or logic-verbal thought allows human beings to surpass the limits of the immediate sensorial perception of external environment, to reflect about connections and complex relationships between information, to form concepts, and to obtain solutions about complex theoretical tasks. Someone that dominates "the word" also dominates a complex system of associations and relations in which an object is included. This complex system was constructed through the personal history (ontogeny) of each individual and also through the History of mankind (phylogeny).

Each word has two components: material representation and meaning [Lra91]. The first enables the humans to evoke images of objects even when they are not present. And the second allows abstracting and generalizing information about some object putting it in a determined category. In this last case, the *intonation* that is used and the associated *context* are placed together with the word to define the specific meaning.

The meaning of a word goes through complex evolution during the ontogeny and phylogeny processes. The material representation usually stays the same but the meaning of that word is enlarged by means of new connections with other psychological constructs and social experiences. This process is called *formation of concepts* [Vyg86][Lra91]. Each concept in someone's mind includes a set of sensorial information and a complex system of logical *ordinate, subordinate, and superordinate categories*. This forms a hierarchical organization known as the semantic structure of a word. According to Luria, such structure is the foundation of the movement of the thoughts. Therefore the *semantic memory* proposed by Tulving can be considered in accordance with Luria's ideas about *word* and *concepts*.

For the purpose of this work it will be assumed that the structure of knowledge called *semantic memory* is the main framework of interconnection of all kinds of information in the human mind. This framework is able to connect all kinds of sensorial information, *propositional* structures and *schematic* models. The words "cognitive" and "knowledge" are used here for all the structures of information, which comprehend all kinds of sensorial information and verbal structures. In next section, these structures of knowledge are analyzed as fuzzy sets.

5.2.3 Mental Representations as Fuzzy Sets

The emotional and motivational processes still puzzle scientists. Several models have been proposed but all of them have some constrains that do not explain all the issues related to this matter. Due to the complexity of the human mind, different points of view can be taken to design a model that simulates the mental processes including emotion and motivation. In this section mental representations will be analyzed from the point of view of Neural Networks, Fuzzy sets and Fuzzy Logic. A mental representation will be regarded as a net of knowledge, which can be taken as a fuzzy set, also the advantages of such modeling will be discussed.

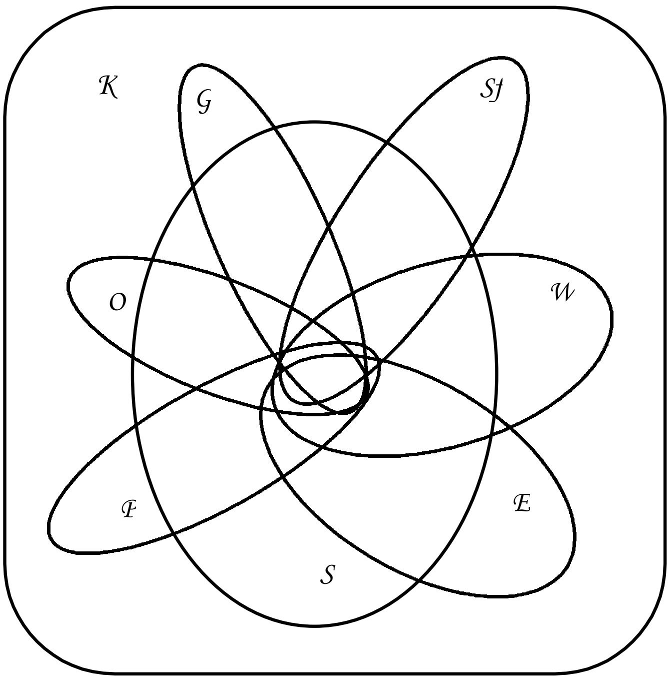
One of the greatest challenges of modeling cognitive and emotional process is to take into account the relationship among different kinds and organizations of information. If someone imagines the brain as a large neural network then there would be a really enormous number of *hidden patterns* of information organization that represents the psychological reality. Furthermore, due to the learning capacity of neural networks, some patterns of information could be combined with each other establishing new other patterns or even new ones can be constructed. These patterns form frameworks, which can be regarded as mental representations.

If someone takes a strict standpoint of neural network, then it will be necessary to stand for each neuron and only the combination of millions or billions of neurons might represent the psychological constructs. Indeed, this idea gets closer to the biological reality of the nervous system in which the psychological reality emerges. However, to simulate such model many technological constraints would have to be created for a computational accomplishment of such enormous neural network. The amount of computational memory and processing speed would have to be the greatest limit of that implementation. Then a possible solution could be to represent clusters of neurons related to mental representations instead of representing each neuron. These clusters would be assumed as specialized neural networks that perform specific tasks.

All knowledge in the mind is highly interconnected as fractal fashion net. In this large net there are many patterns of organization of knowledge. These patterns form cognitive structures, i.e., mental representations. These structures can be accessed by means of perceptual mechanisms or by means of other cognitive processes. The access can be done just by driving isolated information or a set of different information as in the case of synesthesia phenomena [Dlt83]. There are many frames of intersection among these structures due to the massive number of interconnections. Then a mental representation is assumed here as a cluster of interconnected neurons aggregated according to some pattern/structure of similarity. This last assumption will be expanded in order to obtain a new way to see the mental representations.

Each cluster of neurons (mental representation) is taken as a fuzzy set. Therefore, as in fuzzy set logic, it does not have a precise limit that defines what belongs or does not belong to that set. Also such fuzzy set can include subsets or can take part as a subset of another broader one. It can also include information that belongs to other clusters (intersection) or some that are exclusive of itself. Logic operations with a fuzzy set are possible with these clusters. As in Fuzzy Set Logic the intersection of one set with another one is established by a *degree of membership*. Therefore, for the purpose of this present work it will be assumed broader fuzzy sets shown in Figure 5.1:

It could be defined a quasi-infinite number of sets that would represent the mental structures of knowledge. Figure 5.1 illustrates the fuzzy sets $\mathcal{K}$, $\mathcal{S}$, $\mathcal{E}$, $\mathcal{P}$, $\mathcal{G}$, $\mathcal{Sf}$, $\mathcal{O}$, and $\mathcal{W}$ define the main structures of knowledge considered by Tulving [Tul85] and Power and Dalgleish [PwD97]. The fuzzy set $\mathcal{K}$ is a universal set of someone's whole mental knowledge. It indeed stands for all mental information present in someone's mind. The fuzzy sets $\mathcal{S}$, $\mathcal{E}$, and $\mathcal{P}$ stand for the structures of knowledge known as *semantic memory*, *episodic memory*, and *procedural memory* respectively according to Tulving's model. And the fuzzy sets $\mathcal{G}$, $\mathcal{Sf}$, $\mathcal{O}$ and $\mathcal{W}$ respectively represent *goal* representations, *model of the self*, *model of others*, and *model of the world* according to Power and Dalgleish's model. All of those structures include a great quantity of elements, which are extremely interconnected with each other. Many of these elements are common to several sets, that is, they can belong to several sets at the same time. Such elements can be a single neuron or more complex structures of knowledge. In Figure 5.1 sensorial information is not directly represented because it is the raw information that has come from the external world and inner bodily sensors without specific meaning organization. It is important to say that in this figure the *semantic memory* is illustrated as a fuzzy set that is mainly responsible to interconnect the other ones. Further, this idea will be stressed.



K = Fuzzy set of someone's whole mental ***K****nowledge*
S = Fuzzy set of all knowledge organized as in the ***S****emantic memory*
E = Fuzzy set of all knowledge organized as in the ***E****pisodic memory*
P = Fuzzy set of all knowledge organized as in the ***P****rocedural memory*
G = Fuzzy set of all knowledge organized as ***G****oals*
Sf = Fuzzy set of all knowledge organized as model of the ***S****el****f***
O = Fuzzy set of all knowledge organized as model of the ***O****thers*
W = Fuzzy set of all knowledge organized as model of the ***W****orld*

Figure 5.1 – Broader fuzzy sets present in psychological reality.

It will be called *Concepts* fuzzy subsets belonging to those broader ones presented in Figure 5.1. A *Concept* fuzzy set is taken as a small structure of knowledge that stands for an idea about something, a small mental representation. It is expressed by means of verbal language and semantic relations, but it also incorporates sensorial information and represents an integrated unit of knowledge. The sensorial information is not directly dealt with, instead, it is present as part of the whole information. A *Concept* also has a *power set* and shares subsets with other ones.

The use of Fuzzy Logic enables to represent the vagueness of the psychological reality. Psychology often used metaphors and analogies to explain psychological reality. Fuzzy Set and Fuzzy Logic used to see mental reality, allows applying mathematical operations of sets keeping a balance among questions as logic, qualitative sense, imprecision, ill-defined frontier among structures of knowledge, possibility of different organizations of the information, possibility of elements to belong to several sets, etc. Therefore, fuzzy representation of mental reality enables a comprehensive approach of several aspects of psychological constructs.

5.3 Emotion, Motivation, and Personality – Relevant Issues

The models of emotional and motivational processes presented in Chapter 2 have some constrains. One of the main constrains is the modeling of parallelism of the mental processes and the integration among information. The SPAARS (see Figure 2.2) model proposed by Power and Dalgleish [PwD97] is very broad and presents parallelism in a high level of theoretical abstraction. But these authors also assume that emotional process always involve a sequence of events (*event, interpretation, appraisal, action potential, physiology change, and conscious awareness*). Therefore, even with the abstract model proposed in SPAARS showing concurrence between processes, the emotional process is taken as a temporal chain of events.

The model proposed by Ortony et al. [OCC88] (see Figure 2.3) is sequential and it could be represented as a "*production system*" used in Artificial Intelligence (*IF_THEN_ELSE*). Ortony's model was developed bearing computational implementations in mind. In fact this model has been used in computational models associated with *Fuzzy Logic, Production Systems,* and *Rule Based Systems* (e.g. [Cnm97][UHH98]). But it does not take into account parallelism among processes..

Stein et al. [STL93] proposed *a general model of evaluation and planning processes in emotional experience* (see Figure 2.4) that is also sequential. This flowchart puts together aspects such as perception (*Identify event*), expectancy (*Detect belief discrepancy*), goals and plans. This model is broad because it put aspects of cognitive, emotional, and motivational processes together. But for a computational implementation, there are stages of that model (*Determine relevance of event for goals*, *Assess certainty of goals success or failure*, etc.), which would need to be further detailed in order to structure them as a *production system*. Probably all of these stages occur in a parallel fashion as in a neural network, but the authors have just taken a flowchart as a loop. Therefore, this model is restricted because it does not show simultaneity and non-linear interference among mental processes.

The model proposed by Bower [Bwr81] is very interesting since it represents emotion as a semantic net. The main idea in this model is how an external or internal stimulus might activate some nodes and spread out in a selective way other nodes. This idea is closer to a neural network than the other ones. But, this model constrains the nodes and the connections among them in a semantic net under the form of propositions or verbal statements. He slightly mentioned that net connection would be related with ideas, with physiologic systems, with events, and muscular patterns of expression. These last aspects were not sufficiently explained along his paper. He did not associate emotion, motivation, goals, plans and individual differences.

Beyond the aspects mentioned above there are other authors [Rev92][STL93][Frd92] that have treated issues related to goals, plans, personalities traits, and motives as important aspects of cognitive, emotional, and motivational processes. For these authors, motivation and emotion are very connected with these aspects. Goals, plans, and motives are cognitive structures that impose direction and energy to behaviors. Goals and motives are very similar and they are associated with some degree of importance or value, i.e., some goals or motives have more importance than other ones. Some authors [OCC88][PwD97] assume that goals are organized in a hierarchical framework. Depending on how important it is to attain or avoid a goal more or less energy (mental and bodily) will be spent on directing the behavior. Energy is a generic name of several aspects that act together such as attention, concentration, hormonal rate in the blood, muscle activity, etc. This energy makes someone have different bodily and mental sensations in driving his/her behavior to cope with different situations. In addition, personality traits are correlated with personal preferences and motives and also depend on some biological features of each person. This fact leads an individual to have different inclinations and motivations in their behavior [Rev92]. Different personalities imply different motives to act. So, the personality traits cause different motivations and emotions in individuals facing the same circumstances.

Therefore, in spite of the many models of cognitive, emotional, and motivational processes, they are not completely understood. The psychological reality that emerges from the biological informational system (nervous system, endocrine system, and circulatory system) is very elaborate and makes possible many approaches. There are several levels of organization of information, from the biological level (neurons and synapses, and hormones) to complex and abstract cognitive structures (as models of self, others, world, and goals). The structures of knowledge can work together generating many possibilities of operation, i.e., activation of meanings in mind or actions in the body. Until now, this parallelism and integration of information are not sufficiently described by the current approaches. Then it is necessary for new approaches to consider these last aspects and bind emotion, motivation, goals, motives, and personality traits together to design a more realistic model of mind. In order to accomplish this objective, a model of cognitive, emotional, and motivational processes using Fuzzy Cognitive Maps (FCMs) will be defined here. FCMs put Fuzzy Logic and parallelism of Neural Networks together, which makes feasible a more comprehensive model of psychological processes in terms of integration, concurrence, and inexactness among information. Next, this idea will be discussed.

5.4 Mental Reality and Fuzzy Cognitive Maps

This research proposes to model the cognitive, emotional and motivational processes by means of FCMs. This tool links up advantages of Fuzzy Set and Fuzzy Logic with Neural Networks. Fuzzy Set and Fuzzy Logic allow using imprecise information without a defined limit and using logical operation with sets to define action, procedure, etc. In addition, the features of Neural Networks (man-trained [CjT99]) allow modeling parallelism and concurrence among information, which is an important characteristic when someone wants to describe how the psychological processes work.

FCMs makes possible to work with nodes (*Concept*s) as a fuzzy set and edges (links) as a fuzzy variable. For the purpose of this research, nodes or concepts will mean a cluster of information in mind (a mental representation) as it was previously explained. The weighted edges that link two nodes will represent the *degree of subsethood* [Ksk86] between two different *Concepts*, i.e., the common information that belongs to one and another in some *degree of membership*. Each edge expresses the direction of causality being depicted by an arrow (directed edge). The weight of the edge indicates how much a node causes (influences, activate, increases, etc.) changes in another one. There are two directed weighted edges in opposite direction between two Concepts each one with a proper value. When the value is zero, no connection is defined in that direction between the two concepts.

Natural language becomes a meaningful and powerful manner of modeling cognitive-emotional psychological constructs. Each *Concept* is associated with a *word* or a *linguistic expression* that is able to stand for an idea about something. Such idea is a small net or a cognitive frame belonging to the whole framework of knowledge in someone's mind. In FCM modeling, a *Concept* is a node, i.e., a fuzzy set, which depicts vagueness and ill-defined limits presents in natural language. Also the causal relation between two *Concepts* is represented by a weighted edge, which is a fuzzy variable. Such relation is the *degree of membership* between them, that is, the "intersection" between the two sets. The set of all of these causal relations depict the integration/interconnection among the information.

Thus FCMs have great potentiality to simulate the mental reality. In addition to the capacities of Fuzzy Set and Fuzzy Logic and Neural Network mentioned above, FCMs make possible to expand the net of information in a more detailed level or even to combine two or more FCMs to represent different levels of abstraction of information. Such possibility makes such representation more flexible and adaptable than the other ones. It also allows predicting the influence of some *Concept*s upon the other ones. Next, the proposal of using FCMs to model emotion, motivation and personality will be explained.

5.5 Modeling Emotion, Motivation, and Personality Through FCM

To carry out this research, some psychological concepts, which belong to broader fuzzy sets, will be chosen. Those broader fuzzy sets are shown in Figure 5.1: *Self*, *Other,* and *World models, Goals* [PwD97], *Semantic memory*, *Episodic memory*, and *Procedural memory*. These will be considered as more general and abstract fuzzy sets. Their *power set* encompass a lot of fuzzy subsets. Some of those subsets will be chosen to represent classes of *Concept*s. Such classes of *Concept*s can include one or more subsets that belong to those broader fuzzy sets. The classes of *Concept*s are defined here as: *Emotion* (12 instances), *Personality and motivational aspects* (12 instances), *Meta-goals* (4 instances), *Aspects of the self* (3 instances), *Meta-action* (4 instances), *Expectancy* (1 instance), *Aspects of the environment Job/School* (12 instances). *Concept*s are ideas subordinated of one of these categories. Figure 5.2 illustrates this notion. In the top part of the figure there is a rectangle

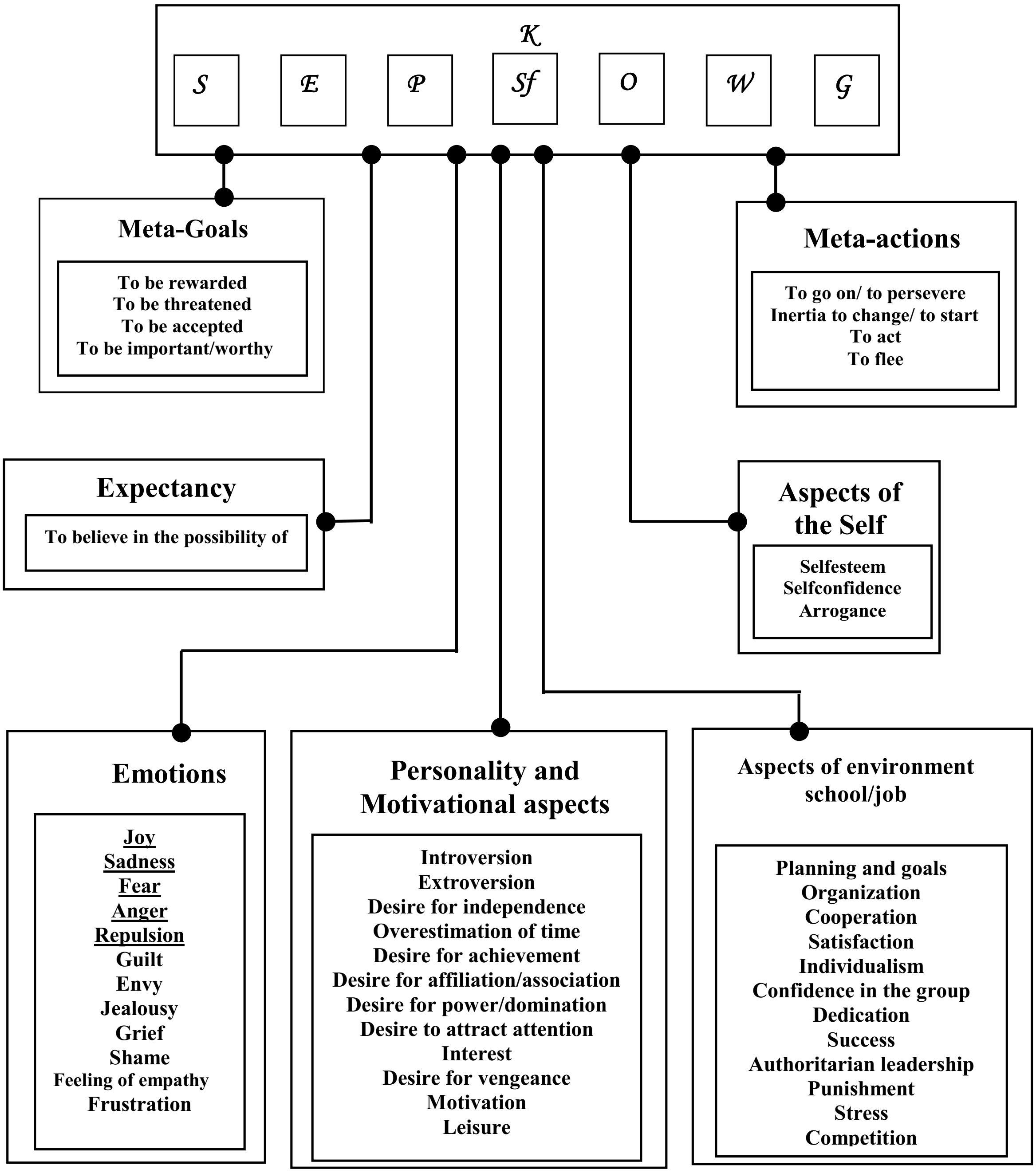


Figure 5.2 – Framework of knowledge divided in Classes of *Concept*s.

equivalent to the same shown in Figure 5.1, which represents the more general structure of knowledge. The other rectangles below that one represent some classes of *Concept*s. There are inside each rectangle instances of each class of *Concept*s. These instances totalize 48 *Concept*s. The criteria of choice such *Concept*s will be discussed in Chapter 6.

Each *Concept* (a *word* or *linguistic expression*) abstracts and generalizes an idea about one or more mental representations. But their level of abstraction and generalization is lower than those broader fuzzy sets and *Classes of Concept*s. The small mental representation that stand for a *Concept* can include other words or linguistic expressions (as Bower proposed [Bwr81]), memories of episodes or some generalizations about episodes, procedures of how to act or to reason in some context, sensorial information (visual, auditory and kinesthetic) related to the external or internal world, etc. In this sense, a *Concept* is an element that aggregates a set of information at the mental level. Therefore a *Concept* is an *idea about something* expressed in a linguistic fashion and represented as a fuzzy set. In this sense a *Concept* is a net of information or a frame of knowledge that can be driven by several input information patterns. In this work the name of a *Concept* (*word* or *linguistic expression*) will drive the meaning (idea) associated with it. This way of thinking about *Concept* as a mental representation close to Ford's idea of BES [Frd92] explained in Chapter 2.

These *Concept*s are put in an FCM as nodes connected to weighted edges (links). The value of weighted edge will stand for the causal relation between the *Concepts*. At first, each node has connections with all the other ones, but in practice many values of the weighted edges will be zero.

The opinion of psychologists about the causal relations between the chosen *Concept*s, i.e., the value of weighted edges, will be investigated. For them to figure out such relationship a *Context* and a *Reasoning Schema* will be suggested. *Context* is a fuzzy set related with information in *Episodic Memory* representing a specific context. The definition of this context is required to improve the specification of the meaning of the *Concept*s, that is, to decrease the number of possibilities of interpretation. *Reasoning Schema* is another fuzzy set related with information in *Procedural Memory*, which will define the logic relation to be looked for among the *Concept*s. So, in order to get the weighted edges each psychologist should make the following logic operation:

$$w_{ij} = Concept_i \cap Concept_j \cap Context \cap Reasoning\ Schema \qquad (4.1)$$

Where:

w_{ij} = value of weighted edge between $Concept_i$ *and* $Concept_j$

So, to find out the value of weight edges the expert has to do the logic operation shown in Equation 4.1. The intersection among the fuzzy sets $Concept_{i,}$ $Concep_{j,}$ *Context,* and *Reasoning Schema* is the searched value.

The fuzzy variable w_{ij} represents the *degree of subsethood* [Ksk86][KgY95] among these fuzzy sets. Equation 4.1 represents the mental operation to figure out the degree of relationship (membership) between the concepts. The fuzzy set called *Reasoning Schema* indeed represents an appropriate reasoning to lead a correct causal relation among the two concepts and the proposed context. This corresponds to the personal interpretation of what means such relation.

The use of Fuzzy Logic and FCMs to represent psychological reality has some characteristics that can approach mental models as they are in fact: vague, qualitative, without a precise border, with the semantic flexibility inherent to common linguistic terms, and aggregating several kinds of information. Also it allows conceiving the processes in the mind as Fuzzy Set Logic operations permitting different combinations among information – sequential and parallel. These features of FCMs allow developing models closer to the actual mental reality in terms of processing and representation.

5.6 Conclusions

This chapter has analyzed the potentiality of using FCMs to model cognitive processes including emotional, motivational and personality traits. FCMs tie up advantages of modeling through Fuzzy Set, Fuzzy Logic and Neural Networks. These characteristics are very interesting to simulate mental processing because mental representations can be depicted as fuzzy sets and concurrence among information as edges of connections.

Mental representations are structures of knowledge in the human mind. Such structures are frameworks that aggregate information according to some pattern of similarities. These structures are massively interconnected and the edges among them are imprecise. Some of those structures have been regarded as important to simulate the emotional and motivational processes, which are *semantic memory*, *episodic memory*, and *procedural memory*, and *goal* representations, *model of the self*, *model of others*, and *model of the world.* Such mental representations stand for a broader fuzzy set having a great number of subsets. Some of these subsets called *Concept*s will be taken as the nodes of an FCM. Such *Concept*s are defined by *words* of *linguistic expression* but they indeed are smaller frames of knowledge that bind together several kinds of information (not only verbal).

The opinion of a group of psychologists about the relationship among some proposed *Concept*s will be collected. This procedure aims at finding out the value of the weight edge among the *Concept*s. Then the *Concept*s and the value of the edges among them will define an entire FCM. Such FCM will be a model of the cognitive, emotional and motivational processes proposed by this research. The definition, simulation, and analysis of that model will be described further. In the next chapter the methodology to be used in this research will be described.

Chapter 6

METHODOLOGY TO MODEL COGNITIVE, EMOTIONAL, AND MOTIVATIONAL PROCESSES THROUGH FCM

6.1 Introduction

This chapter explains the objectives of this work and the methodology chosen to develop the research. The main objective is to generate a new model that places cognitive, emotional, and motivational processes and personalities traits together by means of FCMs. There are several models in Psychology that try to explain mental reality but all of them show constraints that limit representations. This work intends to contribute with a new view of psychological processes. In addition to the concurrence among information characteristic of FCMs, a new way to conceive mental representation is proposed (Chapter 5). Mental representations are treated as fuzzy sets, and so, they get the mathematical facilities to deal with this kind of logic.

FCMs make possible to model in an integrative manner the psychological processes because they place parallelism and vagueness together. In this research, the nodes of FCM are psychological concepts, which are fuzzy sets standing for a mental representation. The definition of the concepts is mainly based on Tulving's and Power and Dalgleish's ideas about organization of knowledge and emotion and motivation. These ideas were taken to describe classes of concepts and an expert helped to define instances of those classes and to adjust the words and linguistic expressions to the correct meaning in Portuguese. Forty eight instances of concepts were defined belonging to seven classes: *Emotions*, *Personality and motivational aspects*, *Meta-goals*, *Aspects of the self*, *Meta-actions*, *Expectancy*, and *Aspects of environment job/school*. This last class was defined with the objective of analyzing the consequences and interaction of emotional and motivational processes in the professional and scholar area.

Starting with those concepts, a questionnaire was defined to obtain the opinion of psychologists. The format of that questionnaire was specified after some interaction with some experts in Statistics and Psychology. The questionnaire is going to be applied to a group of psychologists. The objective is to get the value of weighted edges as a fuzzy variable. The questionnaire totalizes 2304 questions, which correspond to all pairs of direct combinations among all the concepts. The information collected by questionnaires will define an FCM, which will synthesize of all expert's opinions. In further chapter this model will be analyzed in terms of its potential and limitation to represent the psychological reality.

6.2 Objectives and Methodology

The objective of this research is to generate a model of emotions and motivation working together with goals, motives, personality traits, and actions to help planning and diagnosing in productive/commercial and scholar environments. Such model will be based on psychologists' beliefs about this subject. In chapters 2 and 5, it was demonstrated how interconnected these aspects are from the standpoint of information processing.

To accomplish an FCM that models the cognitive, emotional, and motivational processes, which is the goal of this research, it is proposed a *methodology* that has the following steps:

1. definition of the concepts and the their number;
2. development of a questionnaire to collect information about the causal relation (weighted edges) among the concepts;
3. application of the questionnaire to a group of psychologists;

4. definition of the FCM based on the questionnaires answered;
5. analysis and assessment of the results.

The *definition of the concepts and their number* is explained in detail in the next section. The concepts will be chosen from the specialized references about cognition, emotion, and motivation. Forty eight concepts will be used related to emotions, personality and motivational aspects, goals, actions, aspects of self, expectancy, and aspects of environment job/school. Such concepts will be the nodes of an FCM. Then, by means of a questionnaire the weighted edges will be obtained.

The *development of a questionnaire to collect information about the causal relation (weighted edges) among the concepts* was carried out trying several layouts and combination among the information. As result of such proceeding the questionnaire is composed of a total of 2304 questions, divided in 48 pages with 48 questions. All pages have the same layout except by the heading. Each concept should be compared to all others and itself to get the causal relations, i.e., weighted edges. The question in the top (heading) is, for instance:

1. Does joy cause ….

1. *… joy?*
2. *… sadness?*
3. *…*

The answer for each question should be responded by putting an X in one of 7 blank small squares. The 7 options to be answered are: *much increase* (AM), *increase* (A), *little increase* (AP), *non-cause* (NC), *much decrease* (DM), *decrease* (D), and *little decrease*

(DP). These answers stand for a linguistic fuzzy variable. The questionnaire is written in Portuguese because it aims to be applied to Brazilian experts.

The questionnaire allows relating the concept with itself. In the original idea proposed by Kosko [Ksk86] such kind of relation did not exist but Stylios and Groumpos [ScG00] (see item 4.6) proposed *self-feed FCM* in which this idea is possible. Allowing this possibility in the questionnaire, it could be tested if the psychologists believe that a concept is able to influence itself (reinforcing or weakening).

The questionnaire is accompanied by a written explanation about how to answer it and by a *glossary* (see Appendix A). The written explanation describes the objectives of this research, the procedures to fill the form, etc, i.e., some general directions. The *glossary* aims to help the understanding of the concepts trying to get the meaning closer to the objectives of this research. Obviously the meanings of the concepts just get less imprecise. In Figure A.1 (Appendix A) the layout of the questionnaire is shown and the directions to fill it and the glossary of concepts are included.

The *application of the questionnaire to a group of psychologists* will be done with a group of 10 experts chosen. It is considered that they dominate these kinds of concepts in terms of deep meaning. A causal reasoning is proposed to get a degree of causality as answers. Such kind of reasoning sometimes is hard and much logical for psychologists. They are not used to dealing with this way of relating concepts. They are frequently used to making this assertion: “X causing Y *depends on* each case, other factors, etc.”. A previous talk with some psychologists about the questionnaire has shown their reasoning linked to "*depends on*". Then, in the directions to fill the questionnaire, it is defined when "*depends on*" appears in their judgments means that no direct causal relation exists. In such cases it is suggested to experts to answer "*non-cause*" or a weak relation as "*little increase*" or "*little decrease*" according to their points of view. In addition, experts' interpretation and the willingness in answering the questionnaire are important factors to obtain their actual beliefs about such questions.

The chosen context is the *environment job/school* because there is a special interest in its analysis. It is necessary to define a context because the meaning of a word or linguistic expression depends on a specific context. The chosen context is especially interesting to the Production Engineering Program at UFSC due to the importance of the study of the relations and negotiations among employees, employers, clients, companies, etc. In this area, human beings are the main agents. Thus, if someone were able to understand the psychological issues involved in such relations, it would be possible to improve the way to deal with them. Emotions and motivation are strong energies that influence the intensity of the behaviors helping to make people get along together or making relations difficult and unproductive.

Moreover, in the last years the scholar environment has been of interest at the Production Engineering Department at UFSC especially, *distance learning*. In scholar environment as in the productive/commercial areas, factors as emotions and motivation are important aspects of teacher/student and student/student relations. Emotions and motivation can facilitate or hinder interpersonal relations influencing the process teaching/learning. The emotional value of the information increases assimilation of the contents and a high degree of motivation makes someone pursue his/her goals of learning with more enthusiasm and efficiency.

The final steps "*definition of the FCM based on the questionnaires answered*" and "*analysis and assessment of the results*" will be done through totalizing of the questionnaires, simulation of situations, and analysis of the results.

The objective to model the emotional and motivational processes by means of FCMs is to generate a tool to analyze these questions. An FCM can be used to investigate the implications that some active concepts cause in the general aspects of the professional relations including generation of emotions and motivation. Also, FCMs can help in diagnosis of some current situations and in the prediction of probable problems in the future. In addition, if necessary, some new concepts could be included to help dealing with these questions.

6.3 Model of Emotion, Motivation and Personality

In chapters 2 and 5 several questions were addressed related to mental representations and cognitive, emotional, and motivational processes. Mental representations are structures of knowledge present in the human mind that mediate the relationship between an individual and the physical reality. Such structures of knowledge form a massive net of interconnections, which can be analyzed considering several points of view. For the purpose of this research, structures of knowledge known as *semantic memory*, *episodic memory*, and *procedural memory* according to Tulving's [Tul85] model and *goal* representations, *model of self*, *model of the others*, and *model of the world* according to Power and Dalgleish's [PwD97] model will be taken into consideration. Such structures place sensorial and linguistic information together and organized according to some patterns of similarity. The boundary among those structures is not precise and they share several frames of information with each other.

Figure 5.1 illustrates the fuzzy sets $\mathcal{K}$, $\mathcal{S}$, $\mathcal{E}$, $\mathcal{P}$, $\mathcal{G}$, $\mathcal{Sf}$, $\mathcal{O}$, and $\mathcal{W}$, which define the main structures of knowledge considered here. These structures are modeled as fuzzy sets and represent high level of abstraction and generalization of information. In Figure 5.2 subsets of those structures specified as some *Classes of Concepts*. These classes are related to emotional, personality and motivational aspects, goals, expectancy, actions, aspects of the self, and aspects of the environment job/school. The choice for these classes is to place the relevant aspects of cognitive, emotional, and motivational processes together and to analyze the influence of these in the action and in the professional/scholar environments. Each Class of Concept shows some instances, which will be investigated. An expert[6] helped the definition of the format of the questionnaire, the instances of the concepts, and adjustment to the correct meaning in Portuguese.

In the class named *Emotions* 12 concepts were chosen: *Joy, Sadness, Fear, Anger, Repulsion, Guilt, Envy, Jealousy, Grief, Shame, Feeling of empathy,* and *Frustration*. Many authors have considered the five first emotions (see Figure 5.2 - Emotions class-underlined instances) as basic emotions from which the other ones derive. Here *repulsion* was taken instead of *disgust* (real basic emotion). This change was made because *disgust* is

[6] See footnotes on page 119

originally related to digestive processes. In the social context, where it will be investigated, it seems more appropriate to take *repulsion* as a facet of *disgust*. *Guilt*, *envy*, *jealousy*, *feeling of empathy* (a facet of *compassion*), and *shame* were chosen due to their social aspects. *Guilt* and *shame* can work as factors of self-adjustment or control of an individual in a social environment. *Envy* and *jealousy* generally are brought out when dispute or concurrence (real or imaginary) among individuals are present. *Feeling of empathy* is similar to the interpersonal intelligence proposed by Gardner [Gdh95]. This feeling can help to improve agreement and understanding among individuals. Finally *frustration* was chosen due to the fact that this emotion is common during the execution of tasks. Knowing how to deal with this last emotion is important because it allows individual to be persistent in the accomplishment of his/her goals.

In the class named *Personality and motivational aspects* 12 concepts were chosen: *Introversion*, *Extroversion*, *Desire for independence*, *Overestimation of time*, *Desire for achievement*, *Desire for affiliation/association*, *Desire for power/domination*, *Desire to attract attention*, *Interest*, *Desire for vengeance*, *Motivation*, and *Leisure*. The first four concepts are especially related to some personality aspects according to Reeve's [Rev92] analysis. Indeed, *Desire for independence* and *Overestimation of time* were taken respectively as *Desire for control* and as *time urgency* because in Portuguese the meaning of the first two expressions are closer to that proposed by the author. Reeve considered *Desire for achievement, Desire for affiliation/association, Desire for power/domination* as important motives of individuals. He based this consideration on Murray's ideas [Mry38] about human needs. *Desire to attract attention*, *Desire for vengeance*, and *Leisure* are also based on Murray's ideas about, respectively, the needs for *exhibition*, *aggression,* and *play*.

Some authors (e.g., [Rev92]) consider *Interest* as a basic emotion and it can also be related to Murray's study as the need for *understanding*. *Interest* can lead someone to engage in actions to solve problems, to understand another person, etc. *Motivation* is the resulting energy of psycho-physiologic aspects that leads someone's behavior to some particular direction. In Portuguese this word is often used when someone have a great positive expectancy in attaining some goal.

In the class named *Meta-goals* 4 concepts were chosen: *To be rewarded*, *To be threatened*, *To be accepted*, *To be important/worthy*. It received this name because the prefix "*meta*", in this case, means that those concepts are beyond the idea of goals or in a category above. Goals mean specific situations in the future that someone wants to attain or to avoid. So *Meta-goals* are very general objectives that could be accomplished in several situations, not just in a specific one. The meta-goal "*To be rewarded*" is related to the need for achievement [Mry38][Rev92] but in a more specific way, that is, to get something from someone else in recognition to some action or attitude. "*To be threatened*" is meta-goal of avoidance, that is, to avoid or to stay away from threatening situations. People spend energy going toward their desired goals, but also spend energy fleeing from undesired situations. The meta-goal "*To be accepted*" is related to an individual's purpose of feeling accepted by the other ones as part of a group/team/family. It is also related to the need for affiliation [Mry38][Rev92]. And the meta-goal "*To be important/worthy*" is related to an individual's purpose of feeling important and worthy to other people.

In the class named *Aspects of the self* 3 concepts were chosen: *Self-esteem*, *Self-confidence*, and *Arrogance*. The concept "*self-esteem*" and "*self-confidence*" are related to someone's positive feeling and confidence about oneself. And "*arrogance*" is related to the excessive pride about oneself and about one's social importance.

In the class named *Meta-actions* 4 concepts were chosen: *To go on/ to persevere*, *Inertia to change/to start*, *To act*, and *To flee*. As in the *Meta-goals* class, this class received this name because of the prefix "*meta*", in this case, means that those concepts are beyond the idea of a specific action being related to general classes of actions. *Meta-actions* are kinds of general procedures associated to small acts that are carried out as in sequence to execute a more elaborate task. The concept *To go on/to persevere* is related to someone's capacity to persist with a behavior or intention in spite of the difficulties found. The concept *Inertia to change/to start* is related to the difficulty that someone has in changing an under going behavior or in starting an action. The concept *To act* is related to someone's capacity of carrying out or practicing something as an agent. And the concept *To flee* is related to someone's capacity of escaping from a situation, person or object.

In the class named *Expectancy* only one concept was chosen: *To believe in the possibility of*. Such concept is related to someone's belief about the chance that something can happen. This belief guides someone to plan or to act in an appropriate way according to his/her expectation. Stein et al. [STL93] talked about *belief discrepancy* and *evaluate belief system* as factors associated with the generation of emotions (see Figure 2.4).

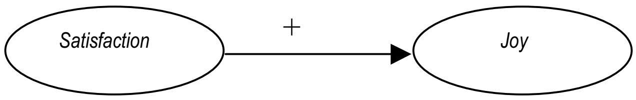
Finally, in the class named *Aspects of environment job/school* 12 concepts were chosen: *Planning and goals*, *Organization*, *Cooperation*, *Satisfaction*, *Individualism*, *Confidence in the group*, *Dedication*, *Success*, *Authoritarian leadership*, *Punishment*, *Stress*, and *Competition*. Such class of concepts was especially chosen because this research intends to analyze the influence of emotions and motivation in the professional and scholar environment as it was previously explained. The concept *Planning and goals* is related to the clear definition of objectives and steps to be performed in a project. The concept *Organization* is related to order in the physical and social environment. The concept *Cooperation* is related to working together in a collaborative way. The concept *Satisfaction* is related to the individual approval of what is/was happened. The concept *Individualism* is related to an egocentric conduct and feeling. The concept *Confidence in the group* is related to the feeling of safety about fellows' attitudes and intentions. The concept *Dedication* is related to the determination of doing a task. The concept *Success* is related to the positive results achieved the completion of an action or a project. The concept *Authoritarian leadership* is related to the imposed and despotic direction taken by a leader. The concept *Punishment* is related to some penalty imposed on someone due to an inadequate behavior or performance. The concept *Stress* is related to the excessive tension or number of solicitations in carrying out tasks. And the concept *Competition* is related to the dispute among individuals to have advantages over the others, to get position or something, or better performance in tasks. These concepts were chosen associating some aspects of emotion and motivation cited by Reeve, Power and Dalgleish, and Stein et al. with some aspects commonly considered as important in job/school environments.

Each concept will be a node in an FCM. The weighted edges among the concepts are going to be determined through a research with experts. These concepts are represented by *words* or *linguistic expressions*, which are imprecise and without a defined boundary, as it is expected when the natural language is used. The FCM nodes are fuzzy sets, which have been shown to be a good tool to model such characteristics of natural language.

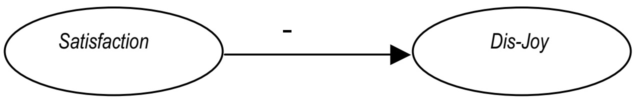
According to Kosko [Ksk86], the nodes of an FCM are variables (concepts) represented as fuzzy sets. He defined a generic concept Ci as a fuzzy union of some fuzzy quantity set Qi and associated dis-quantity set ~Qi, that is:

$$Ci = Qi \cup \sim Qi \quad (6.1)$$

Where ~Qi can be thought of as the abstract negation, or local fuzzy complement of Qi. Consequently, a concept also has in itself its logical negation. For instance, if it is considered the concept *Satisfaction* increasing the concept *Joy*, as shown in Figure 6.1 (a), it could also take as true its logical negation as shown in Figure 6.1(b). Then the concept *Satisfaction* also decreases the concept *Dis-joy*. Therefore, deductions can be made to get other logical relationships among the "*Dis*-concepts".



(a)



(b)

Figure 6.1 – (a) Hypothetical relation between the concepts *Satisfaction* and *Joy,* (b) Logical deduction from (a).

Based on this idea Kosko considered that it is not necessary to represent in the same FCM a *concept* and its "*dis-concept*" because the logical relationship can be inferred easily. But in the case of the 48 concepts proposed in this work there are some that can be considered antonyms such as *Joy* and *Sadness* and *Extroversion* and *Introversion*. But such concepts were put together because due to the imprecision of natural language it is believed that the antonym does not mean the same as logical negation. For example: Would *dis-joy* mean *sadness*? Or would *joy* mean *dis-sadness*? So, an antonym seems different from a logical negation. Beyond this aspects, in common language people have difficulty to process negative forms. Then, probably in the final FCM it will be possible to take some conclusions regarding this question.

Several simulations will be carried out to allow checking how much a concept influences the others. The entry vector C_0 (see Chapter 4) could receive many combinations among the concepts to test situations and predict the resultant conditions. Then the concurrence among information could be better understood. Also comparison with other traditional models of emotional and motivational processes should be done in order to assess the advantages and constraints of such modeling.

6.4 Conclusions

In this chapter the general methodology to model emotion, motivation, and personality by means of FCMs was described. FCMs make possible to represent linguistic concepts in an easy way. Then the proposal of this work is to use psychological concepts as nodes of an FCM. Such concepts were chosen based on Cognitive Psychology works and some aspects of environment job/school. Each concept is a word or linguistic expression in an average level of abstraction. The construction of the model will be done based on a questionnaire applied to a group of psychologists. This questionnaire will assess the relation among concepts, which will be used to define the weighted edges of the FCM. The computation of the questionnaire, analysis of the data, and the analysis of the constructed FCM are the main contribution of this research.

It is believed that the model to be obtained may provide a new way to observe the cognitive processes in a special mental representation. FCM has characteristics of the parallel distributed processing of Neural Network, which is a feature of mental processes. In addition, the concepts correspond to mental representations depicted as a fuzzy set. This last idea is the innovation of this work and it makes possible to see mental representation with imprecision and ill-defined limits as they actually are. Therefore, an FCM model will enable to place parallelism and Fuzzy Logic together defining a simulation closer to the real processes. Such model surely could contribute as a new way to understand and analyze psychological reality.

Chapter 7

IMPLEMENTATION

7.1 Introduction

This chapter presents the main aspects related to the implementation of the proposals shown in Chapters 5 and 6. Basically, it explains how prior ideas have been transformed in mathematics parameters and processed.

In Chapter 5 the advantages of modeling cognition, emotion and motivation through FCM were presented. It emphasized that such technique places together Fuzzy Set and Neural Network features, which have much similarity with mental processing and representation. Chapter 6 discussed the methodology proposed for modeling cognitive, emotional, and motivational processes using FCM. Seven classes of concepts were defined each one divided in some instances. Such instances correspond to 48 concepts that were carefully chosen. Then a questionnaire was developed in order to obtain the FCM weighted edges. Such questionnaire asks the psychologists for all the possible two-by-two relations among the set of 48 concepts.

This chapter presents a general description of the questionnaire, the information collected and how to deal with that. Also, the main aspects of the software that has been developed are described. Four programs in FORTRAN to treat the data collected were developed. The software performs: the data entry, correction and definition of numeric equivalent to the gradations, statistical calculations, and FCM simulation. The first and the second tasks generate the database in a file fashion. The third task generates some general statistics and the "General Average Matrix". This matrix has been taken as the FCM connection matrix (or weighted edges matrix) and it synthesizes the experts' thoughts. This last part is the main objective of this research, i.e., to simulate FCM processing and to analyze the outcomes.

Some practical issues of the implementation have been explained and justified. The numeric approximations are discussed, such as, the choice of numeric equivalent and the threshold function. These aspects perform an important role in the final results influencing the general interpretation of the results.

7.2 General Description

The main objective of this research is to evaluate the use of the FCM technique in the analysis of cognitive, emotional, and motivational processes. The FCM technique demands the definition of a "weighted edge matrix", which represents a net of knowledge about some subject(s). In order to obtain such matrix, Chapter 6 proposed a methodology that consists of the application of a questionnaire to a group of experts (psychologists), and of the computational treatment of the data collected.

The questionnaire layout was carefully defined with the aid of a psychologist and a statistical expert[7]. It consists of 48 pages with 48 questions totalizing 2304 responses. Each page has the same layout and each answer is chosen in a set of seven literal possibilities (NC, AM, A, AP, DM, D, DP)[8]. This sequence seems to be in accordance with the perceptual way that people organize their thoughts. A questionnaire completely answered corresponds to a 48X48 matrix. The questionnaire is shown in Appendix A. Twelve

[7] Psychologist Angelice Amghebem Dias and Prof. Pedro Alberto Barbetta.
[8] NC = *Não Causa* (no cause),
AM = *Aumenta Muito* (much increase), A = *Aumenta* (increase), AP = Aumenta Pouco (little increase),
DM = *Diminui Muito* (much decrease), D = *Diminui* (decrease) , DP = Diminui Pouco (little decrease).

questionnaires were handed over but just nine returned answered. These questionnaires were tabulated and they are shown in Appendix B.

In order to apply the FCM technique requirements, numeric values have to be attributed to each gradation. The numeric proportion among the gradation is a subjective aspect and, at first, there are no correct values for those gradations. For that reason, several relations among the gradation can be tried out. In item 7.4 this issue has been stressed. This numeric approximation is essential to start the calculations and it influences the final results. In this research, the General Average Matrix represents the FCM weighted edge matrix, and it depends on the different numeric equivalents. In FCM simulations this matrix is a fundamental piece of the processing. To calculate such matrix and to make the numerical approximations four computational programs were developed. The next item describes them in general terms.

7.3 Software description

Four programs were developed in FORTRAN 77 to calculate statistical parameters and to make the simulations according to the FCM technique. The first program allows entering with each expert's data and storing them in the computer memory as files. The second program allows correcting the entered data by the first program and it also sets numeric equivalents for the gradations. The third program calculates statistical parameters: frequency of occurrence of the gradations for each expert, General Average Matrix, and the "energy" of each concept. And the fourth program makes the typical operation in FCMs, which is to allow selecting the activation of a concept or some concepts and a threshold criterion to check the stabilization of the system. Appendices C and D show more details about these programs and user interface. Table 7.1 summarizes the general characteristics of the programs.

Table 7.1 – General tasks performed by the developed programs.

Program	Task
1st) **LeArquivaEmocao**	• Tabulation of expert answered questionnaires and other entries into computer files
2nd) **CorrigeEmocao**	• Correction of data in previous computer files (if necessary) • Statement and correction of numeric equivalents

3rd) **PreparaEmocao**	• Selection of the desired numeric equivalent
	• Calculation of:
	    • Frequency of occurrence of each gradation
	    • "Energy" of each concept
	    • Average and standard deviation matrices
	• Generation of files to graphical analysis

4th) **AnalisaEmocao**	• Selection of threshold function • Selection of stabilization criteria • Selection of the active concept(s) • FCM simulation • Generation of result files

The next two items discuss the results obtained with the execution of the 3rd Program – Statistical calculation, and the item 7.6 explains the 4th Program – FCM simulation.

7.4 Numeric Approximation

This item discusses the numerical questions related to data computation. It has been shown and justified the set of numeric equivalents proposed by the software. Also, it has been explained the mathematical methods to calculate the General Average Matrix and some considerations about the "energy" of a concept.

7.4.1 Numeric Equivalent

For a numeric analysis to be performed, it is necessary to associate each gradation to a numeric equivalent. The challenge is to establish a numeric proportion among the gradations that mirrors the experts' beliefs. To increase and to decrease the intensity of a concept is a subjective notion. Thus, for the purpose of this work, it is assumed that the gradation NC always corresponds to the numeric equivalent *zero*, because it models the situation that there is no relation between 2 concepts. The gradation AM always corresponds to 1 (one) or more, i.e., to increase the intensity of a concept once or more. On the other hand, the gradation DM always corresponds to –1 (minus one) or lesser, i.e., to decrease the intensity of a concept once or more. Thus, here will be considered that AM increases a concept one unity or more and DM decreases a concept a unity or more. So, the gradation A and AP, and D and DP will be taken as a fraction of one unity. The software allows choosing or defining some different fractions. The software proposes the numeric equivalents shown in Table 7.2. Figure 7.1 shows these ratios in scale.

Table 7.2 – Categories of numeric equivalents to the gradations proposed by the software.

NC	**AM**	**A**	**AP**	**DM**	**D**	**DP**	Type
0	+1	0.67	0.33	-1	-0.67	-0.33	Linear ratio
0	+1	0.85	0.62	-1	-0.85	-0.62	Golden ratio
0	+1	0.38	0.14	-1	-0.38	-0.14	Reverse golden ratio
0	+1	0.50	0.25	-1	-0.50	-0.25	Square ratio
0	+1	0.84	0.51	-1	-0.84	-0.51	Exponential ratio*

* See footnote 3 (page 123).

The relation between the gradation and numeric equivalent is somewhat subjective then some different numeric equivalents have to be proposed and analyzed. The fractions or ratios shown in the Table 7.2 were chosen to represent numerically the literal gradations answered by the experts, but the software makes possible to try out others that can be stated by the user. The *linear ratio* establishes equal steps between neighboring gradations. The *golden ratio* represents the ancient ratio adopted by Greeks and presents in some proportions that are found in nature [Gcd95]. This ratio was considered in two senses: starting from zero (NC) to +1 and –1 direction, and starting from +1 (or –1) to zero (NC) direction, called *reverse golden ratio*. The *square ratio* adopts the ratio 2 between neighboring gradations. And the *exponential ratio* is based on sigmoid function[9].

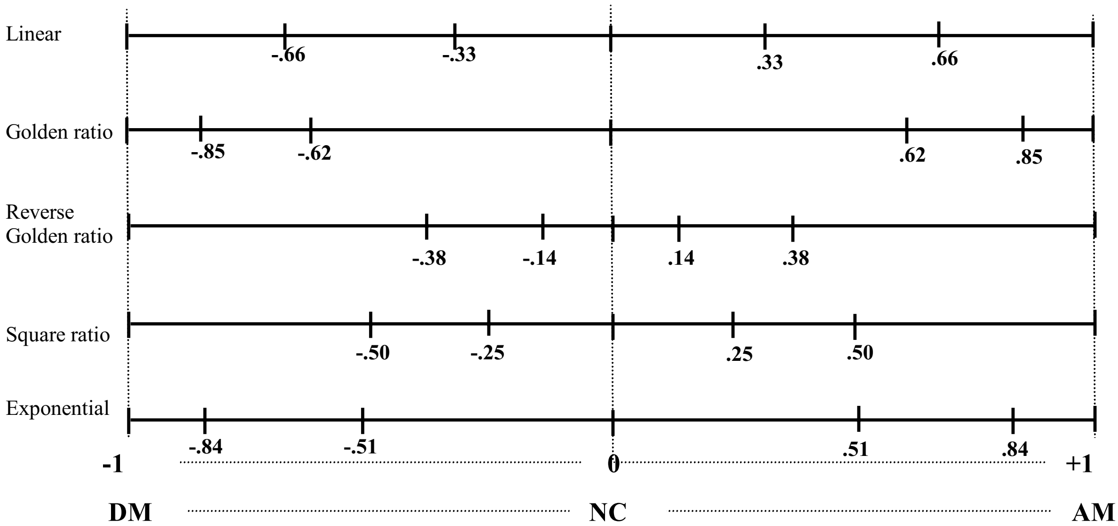


Figure 7.1 – View of the numeric equivalents (in scale).

7.4.2 General Average Matrix

The General Average Matrix is a key element in the simulation because it synthesizes all the data collected. In this research, it will represent the FCM connection matrix. The numeric value of each element of such matrix depends on the chosen numeric equivalent.

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[9] $f(x) = 1.105\dfrac{\left(1-e^{-x}\right)}{\left(1+e^{-x}\right)}$, for $x = 0, \ \pm1, \ \pm2, \ \pm3$

The choice of the numeric equivalent of the gradations is the initial step to start the numeric handling of the data. The experts' literal answers are associated to the corresponding numeric equivalents and then computed. The General Average Matrix is obtained by means of calculating the average value in each position as shown by Equation 7.1.

$$\bar{a}_{ij} = \sum_{n=1}^{NE} \frac{a_{ij}^{n}}{NE} \qquad (7.1)$$

Where:

$\bar{a}_{ij}$ = average value in the position *ij* of the General Average Matrix $\overline{\mathbf{A}}_{ij}$
NE = number of experts
a_{ij}^{n} = value of a_{ij} answered by the expert *n*

For each numeric equivalent it also calculates the standard deviation (SD_{ij}) in each position according to Equation 7.2.

$$SD_{ij} = \sqrt{\frac{\sum_{n=1}^{NE}\left(a_{ij}^{n} - \bar{a}_{ij}\right)^{2}}{NE - 1}} \qquad (7.2)$$

Using Equation 7.2, a General Standard Deviation Matrix is obtained that numerically represents, for each position, the deviation among the experts' responses.

7.4.3 Energy of a Concept

Another aspect related to the numeric equivalent is the "energy" of each concept. The aspect "energy" tries to express how much a concept influences the others and how much the others influence it. The “energy” presents four facets related to the weight of a concept in the whole system, which means:

a) how much it influences positively the others (Activating positively - *Activ+*)
b) how much it influences negatively the others (Activating negatively – *Activ-*)
c) how much it is influenced positively by others (Being activated positively – *BeAct+*)
d) how much it is influenced negatively by the others (Being activated negatively – *BeAct-*)

These parameters aim at evaluating how much a concept influences or is influenced by others. For that, the weight and the occurrence of the gradation AM, A and AP are added and the weight and occurrence of the gradation DM, D and DP are added. Thus, the “positive energy” and the “negative energy” that a concept provides to the others or receives from the others are found. However, such evaluation also depends on the *numeric equivalent* attributed to the gradations.

Items a) and b) (above mentioned) are related to the weights in a line of the FCM connection matrix. In FCMs the computation per line means the capacity of the concept in the activation or causation of the others. This “causation”, in FCMs’ graphs, is represented as an arrow that leaves the node (concept) towards another node. On the other hand, items c) and d) are related to the weights in a column of the FCM connection matrix. The computation per column means how much a concept receives influence of the others. In FCM’s graphs, it is represented as arrows getting to a node.

This kind of analysis is important because it highlights the concepts that have more influence on the others or those that are more influenced by the others. This investigation can be useful in processes such as planning and diagnosis of problems, and to facilitate the discovery of solutions to problems in personal and/or social issues.

The "energy" of each concept was calculated according to Equations 7.3, 7.4, 7.5 e 7.6.

Energy of increasing activation:

$$Activ+ = N^{l}_{AM} \times Eq_{AM} + N^{l}_{A} \times Eq_{A} + N^{l}_{AP} \times Eq_{AP} \qquad (7.3)$$

Energy of decreasing activation:

$$Activ- = N^{l}_{DM} \times Eq_{DM} + N^{l}_{D} \times Eq_{D} + N^{l}_{DP} \times Eq_{DP} \qquad (7.4)$$

Energy of increasing being activated:

$$BeAct+ = N^{c}_{AM} \times Eq_{AM} + N^{c}_{A} \times Eq_{A} + N^{c}_{AP} \times Eq_{AP} \qquad (7.5)$$

Energy of decreasing being activated:

$$BeAct- = N^{c}_{DM} \times Eq_{DM} + N^{c}_{D} \times Eq_{D} + N^{c}_{DP} \times Eq_{DP} \qquad (7.6)$$

Where:

Activ+ = energy of activation increasing other concepts

Activ- = energy of activation decreasing other concepts

BeAct+ = energy of increase being activated by other concepts

BeAct- = energy of decrease being activated by other concepts

N^{l}_{AM} = number of *AM*s in line *l*

N^{l}_{A} = number of *A*s in line *l*

N^{l}_{AP} = number of *AP*s in line *l*

N^{l}_{DM} = number of *DM*s in line *l*

N^{l}_{D} = number of *D*s in line *l*

N^{l}_{DP} = number of *DP*s in line *l*

N^{c}_{AM} = number of *AM*s in column *c*

N^{c}_{A} = number of *A*s in column *c*

N^{c}_{AP} = number of *AP*s in column *c*

N^{c}_{DM} = number of *DM*s in column *c*

N^{c}_{D} = number of *D*s in column *c*

N^{c}_{DP} = number of *DP*s in column *c*

Eq_{AM} = numeric equivalent of the gradation *AM*

Eq_{A} = numeric equivalent of the gradation *A*

Eq_{AP} = numeric equivalent of the gradation *AP*

Eq_{DM} = numeric equivalent of the gradation *DM*

Eq_{D} = numeric equivalent of the gradation *D*

Eq_{DP} = numeric equivalent of the gradation *DP*

These parameters related to the “energy” of the concepts will be employed to define which concepts have more influence on the system than others and which are more influenced by the system. Such concepts will be utilized in the main simulations (Chapter 8) to obtain numeric patterns of the behavior system.

7.5 FCM Simulation

The methodology of simulation is that proposed for FCM modeling already discussed in Chapter 4. In this work, the FCM connection matrix will be the General Average Matrix, which depends on the choice of numeric equivalent. Each set of numeric equivalents generates a different General Average Matrix, and it indeed represents “crisp” values. However, in this work, some fuzzy approximations will be done in other steps of the simulation to get more qualitative results.

7.5.1 Simulation

Chapter 4 explains the procedures to find out the response of the system. Figure 7.2 shows such procedure in a schematic way to clarify the simulation proposed in this research.

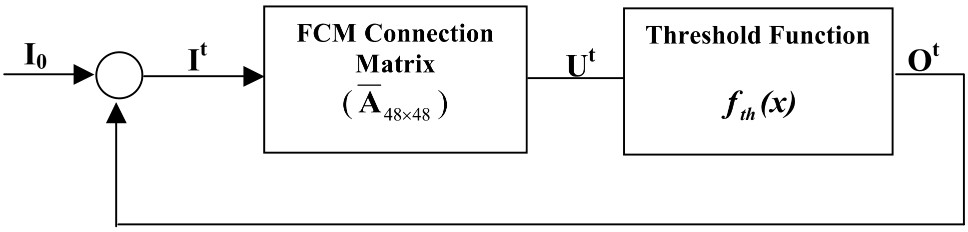

Figure 7.2 - Diagram of simulation procedure.

In Figure 7.2 $\mathbf{I_0}$ represents the initial exciting vector. It has 48 elements, which represent the initial status of the concepts imposed externally to the system. $\mathbf{I^t}$ is the input of the system, and at first $\mathbf{I^t}$ is equal to $\mathbf{I_0}$. $\mathbf{I^t}$ multiplies the FCM Connection Matrix generating an unbounded output labelled here $\mathbf{U^t}$. Equation 7.7 demonstrates this procedure.

$$\mathbf{I}^t_{1\times48} \times \overline{\mathbf{A}}_{48\times48} = \mathbf{U}^t_{1\times48} \qquad (7.7)$$

Where:

$\mathbf{I}^t_{1\times48}$ = input in the cycle **t**
$\mathbf{U}^t_{1\times48}$ = unbounded output in the cycle **t**
$\overline{\mathbf{A}}_{48\times48}$ = FCM connection matrix (General Average Matrix)

The FCM connection matrix - $\overline{\mathbf{A}}_{\mathbf{48\times48}}$ -, in this research, is taken as the General Average Matrix. The vector $\mathbf{U}^{\mathbf{t}}_{\mathbf{1\times48}}$ represents an unbounded "crisp" output. This vector has to be adjusted to get closer to fuzzy values, so it will better express qualitative responses than a strict numeric quantification. Then a function $\mathbf{f}_{th}(\mathrm{x})$ - *threshold function* - makes such adjustment giving a somewhat fuzzy response. A *threshold function* can be defined by each particular project. The output vector $\mathbf{0}^{\mathbf{t}}_{\mathbf{1\times48}}$ is obtained through a procedure summarized in Equation 7.8.

$$\mathbf{O}^{\mathrm{t}}_{1\times48} = \mathbf{f}_{th}\left(\mathbf{U}^{\mathrm{t}}_{1\times48}\right) \qquad (7.8)$$

Where:

$\mathbf{O}^{\mathbf{t}}_{\mathbf{1\times48}}$: output in the cycle t

The new input is the vector $\mathbf{I}^{\mathbf{t+1}}_{\mathbf{1\times48}}$, which is obtained combining $\mathbf{O}^{\mathbf{t}}_{\mathbf{1\times48}}$ and $\mathbf{I_0}$ as it is shown in Equation 7.9.

$$\mathbf{I}^{\mathbf{t+1}}_{\mathbf{1\times48}} = \mathbf{O}^{\mathbf{t}}_{\mathbf{1\times48}} + \mathbf{I}_{\mathbf{0}} \qquad (7.9)$$

Indeed, Equation 7.9 shows a procedure called "clamped" [Ksk91][Mst97]. It is used to hold the vector $\mathbf{I_0}$, which is active during all the calculation. Otherwise, the vector $\mathbf{I_0}$ can be held in the first cycle (or just during some cycles) and then inactivated – "no-clamped". The software allows selecting clamped or no-clamped (holding $\mathbf{I_0}$ just in the first cycle) operations. In each cycle the new input is processed again and the procedure is repeated until a *limit cycle* or *hidden pattern* [Ksk87] is found. This happens when the process gets steady, that is, when the input at the instant $\mathbf{t+1}$ is equal to that in the instant $\mathbf{t}$:

$$\mathbf{I}^{\mathbf{t+1}}_{\mathbf{1\times48}} = \mathbf{I}^{\mathbf{t}}_{\mathbf{1\times48}} \qquad (7.9)$$

7.5.2 Stop Criteria

Also, the process can get steady when a sequence of inputs cyclically appears causing a periodic behavior in the system. The software allows three criteria to stop the iterations:

a) When the present input is equal to the last one ($\mathbf{I}^{\mathbf{t+1}}_{\mathbf{1\times48}} = \mathbf{I}^{\mathbf{t}}_{\mathbf{1\times48}}$)

b) When the present input is equal to one of the last 24 ($\mathbf{I}^{\mathbf{t}+n}_{\mathbf{1\times48}} = \mathbf{I}^{\mathbf{t}}_{\mathbf{1\times48}}$ for $n \leq 24$)

c) Up to 99 iterations

Conditions a) and b) indicate that the "*hidden pattern*" or "*limit cycle*" was found, so there is a response of the system to the input excitation. Condition c) points out that the software did not converge. In this case the response could not be analyzed because more cycles would be necessary or the system would spend immense number of iterations until a repetition could be found.

7.5.3 Threshold Function

The use of the threshold function is necessary to adequate the output values in a range that gives a qualitative notion about the system behavior. High values should suffer a kind of saturation, as it occurs in human sensorial systems[10]. Then the output has to be

[10] For example see http://www.digistar.com.my/rcf/1_1.htm

tuned to avoid great numeric values masking small ones. The program allows selecting 5 different possibilities to the threshold function, which are:

1) Regularization
2) Normalization
3) Trivalent function
4) Septivalent function
5) Sigmoid function

The Regularization threshold function makes an adjustment in the output vector in each cycle as it is shown in Equation 7.10. This adjustment takes the greatest value of the output vector as reference and divides the others by the first. Then the output values do not exceed a unity in modulus.

$$o_j^{t,r} = \frac{u_j^t}{\left|u_j^{t,\max}\right|} \qquad (7.10)$$

Where:

$o_j^{t,r}$ = element of the regularized output vector $\mathbf{O}_{1\times 48}^{\mathbf{t},r}$ in the time **t**

u_j^t = element of the unbounded output vector $\mathbf{U}_{1\times 48}^{\mathbf{t}}$ in the time **t**

$\left|u_j^{t,\max}\right|$ = module of the maximum value element of the unbounded output vector $\mathbf{U}_{1\times 48}^{\mathbf{t}}$ in the time **t**

The Normalization threshold function makes a classical statistical normalization as it is shown in Equation 7.11. For each cycle it is calculated the average value of all the elements present in the output vector as well as the standard deviation. The element of the output vector represents how many standard deviations the unbounded element relates to the average value.

$$o_j^{t,n} = \frac{u_j^t - \bar{u}^t}{sd_u^t} \qquad (7.11)$$

Where:

$o_j^{t,n}$ = normalized element of the output vector $\mathbf{O}_{1\times48}^{\mathbf{t},n}$ in the time **t**
u_j^t = element of the unbounded output vector $\mathbf{U}_{1\times48}^{\mathbf{t}}$ in the time **t**
$\bar{u}^t$ = average value of all the elements in the unbounded output vector $\mathbf{U}_{1\times48}^{\mathbf{t}}$ in the time **t**
sd_u^t = standard deviation of the elements in the unbounded output vector $\mathbf{U}_{1\times48}^{\mathbf{t}}$ the time **t**
For $j = 1{,}48$

The process of normalization and regularization allows a dynamic and adaptive adjustment of the simulation process. In a large matrix such as the General Average Matrix, in the beginning of the FCM calculations, only small values are obtained. But after some iteration the elements in the unbounded vector increase to higher values making the interpretation of the outcomes difficult. Thus, these two adjustments are dynamic, which allow a better adaptability at each time and keeping the values in a proportional scale. The values remain as “crisp” variables no matter how close the fuzzy variables can be, i.e., into the interval [+1,-1]. The normalization is a method that has been used in some software, for example *QwickNet*, which deals with neural networks, and regularization is proposed by this research.

The Trivalent threshold function makes a general adjustment as it is shown in Equation 7.12.

$$\left.\begin{array}{l} o_j^t = -1,\ u_j^t \le -0.5 \cdot \left|u^{\max,t}\right| \\ o_j^t = 0,\ -0.5 \cdot \left|u^{\max,t}\right| < u_j^t < 0.5 \cdot \left|u^{\max,t}\right| \\ o_j^t = 1,\ u_j \ge 0.5 \cdot \left|u^{\max,t}\right| \end{array}\right\} \text{Trivalent} \qquad (7.12)$$

It adjusts the unbounded output vector $\mathbf{U}^{\mathbf{t}}_{\mathbf{1\times 48}}$ in a way to obtain just three possible values to the output vector elements {+1, 0, -1}. The module of the maximum value element $\left|u^{\max,t}\right|$ is taken as reference for the adjustment as in the Normalization threshold function.

The Septivalent threshold function makes a general adjustment in each element of the unbounded vector $\mathbf{U}^{\mathbf{t}}_{\mathbf{1\times 48}}$ as it is shown in Equation 7.13.

$$\begin{array}{l}\text{Septivalent} \\ \text{function}\end{array} \begin{cases} o_j^{t,7} = Eq_{DM},\ u_j^t < F_{DM,D} \cdot \left|u^{\max,t}\right| \\ o_j^{t,7} = Eq_{D},\ F_{DM,D} \cdot \left|u^{\max,t}\right| \le u_j^t < F_{D,DP} \cdot \left|u^{\max,t}\right| \\ o_j^{t,7} = Eq_{DP},\ F_{D,DP} \cdot \left|u^{\max,t}\right| \le u_j^t \le F_{DP,NC} \cdot \left|u^{\max,t}\right| \\ o_j^{t,7} = Eq_{NC},\ F_{DP,NC} \cdot \left|u^{\max,t}\right| < u_j^t < F_{NC,AP} \cdot \left|u^{\max,t}\right| \\ o_j^{t,7} = Eq_{AP},\ F_{NC,AP} \cdot \left|u^{\max,t}\right| \le u_j^t \le F_{AP,A} \cdot \left|u^{\max,t}\right| \\ o_j^{t,7} = Eq_{A},\ F_{AP,A} \cdot \left|u^{\max,t}\right| < u_j^t \le F_{A,AM} \cdot \left|u^{\max,t}\right| \\ o_j^{t,7} = Eq_{AM},\ F_{A,AM} \cdot \left|u^{\max,t}\right| < u_j^t \end{cases} \qquad (7.13)$$

Where:

$F_{DM,D} = \frac{1}{2}\left(Eq_{DM} + Eq_{D}\right)$; frontier between Eq_{DM} and Eq_{D}

$F_{D,DP} = \frac{1}{2}\left(Eq_{D} + Eq_{DP}\right)$; frontier between Eq_{D} and Eq_{DP}

$F_{DP,NC} = \frac{1}{2} Eq_{DP}$; frontier between Eq_{DP} and Eq_{NC}

$F_{NC,AP} = \frac{1}{2} Eq_{AP}$; frontier between Eq_{NC} and Eq_{AP}

$F_{AP,A} = \frac{1}{2}\left(Eq_{AP} + Eq_{A}\right)$; frontier between Eq_{AP} and Eq_{A}

$F_{A,AM} = \frac{1}{2}\left(Eq_{A} + Eq_{AM}\right)$; frontier between Eq_{A} and Eq_{AM}

Then the output vector $\mathbf{O}^{\mathbf{t},7}_{\mathbf{1\times48}}$ is a way to obtain seven possible values to the output vector elements:

$\left\{Eq_{AM}\ , Eq_{A}\ , Eq_{AP}\ , Eq_{NC}\ , Eq_{DP}\ , Eq_{D}\ , Eq_{DM}\right\}$ (see Equations 7.3 to 7.6)

These values correspond to the numeric equivalent of each gradation. The modulus of the maximum value element $\left|u^{\max,t}\right|$ is taken as reference for the adjustment. The advantage of this adjustment is to obtain compatible results with the gradation proposed in this research allowing an analysis with similar criteria. Figure 7.3 illustrated the frontiers of adjustment expressed in Equation 7.13 for the Septivalent threshold function.

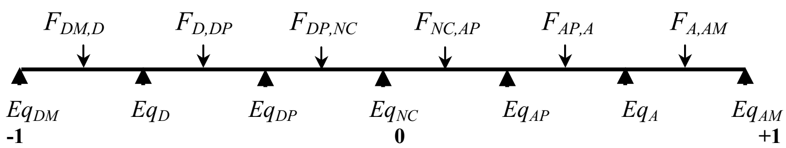

Figure 7.3- Septivalent threshold function and frontier of adjustment of the numeric equivalent.

The Sigmoid threshold function makes a general adjustment as it is shown in Equation 7.14[11].

$$o_j^{t,S} = \frac{\left(1 - \exp\left(-\frac{\lambda}{\left|u^{\max,t}\right|} u_j^t\right)\right)}{\left(1 + \exp\left(-\frac{\lambda}{\left|u^{\max,t}\right|} u_j^t\right)\right)} \qquad \text{Sigmoid} \qquad (7.14)$$

Equation 7.14 is applied to each element in the unbounded output vector $\mathbf{U}_{1\times 48}^{\mathbf{t}}$. It is important to notice that due to the size and numeric values of the FCM connection matrix characteristics, as in prior threshold functions, the unbounded output quickly goes from small values (between 1, -1) to great ones. Then this research suggests that in Trivalent, Septivalent and Sigmoid threshold functions to use $\left|u^{\max,t}\right|$ as reference instead of $+1$ and –1. Thus, in each iteration, the output vector elements are fitted in a desirable interval [+1,1] allowing several values inside that range, not only the extremes. In the Sigmoid threshold function lambda value has to be chosen carefully. Small lambda carries out the output values closer to zero, and great one carries out a quickly "saturation". Figure 7.4 illustrates some Sigmoid threshold function for different lambda values.

[11] This function is a variation of the Equation 4.6.
λ can be chosen by the user.

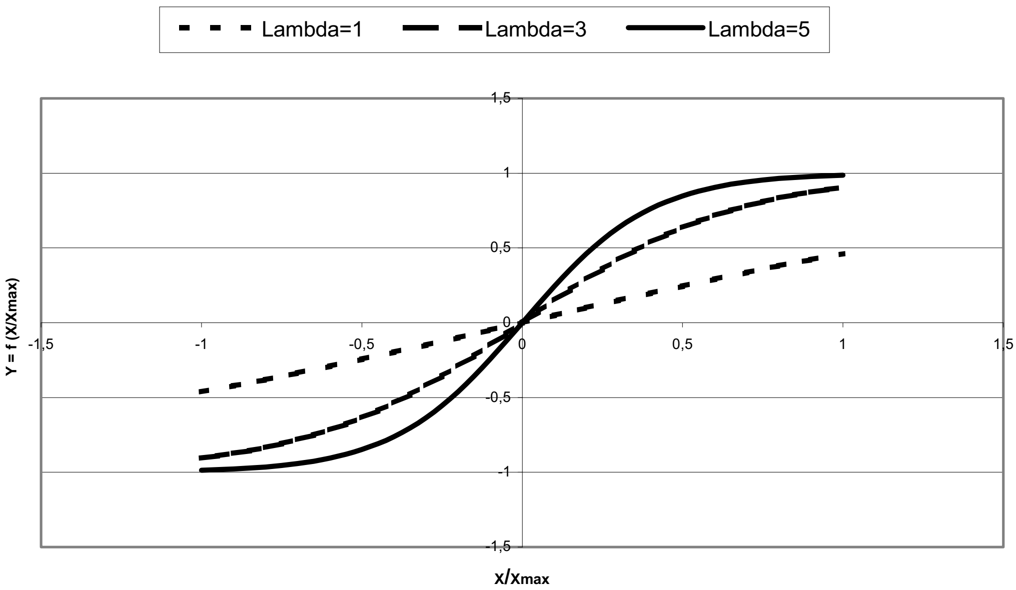

Figure 7.4 – Sigmoids with different lambda values.

7.6 Conclusions

This chapter presented the numeric and practical issues related to the implementation aspects of this research. Details of numeric data treatment were explained and mathematical questions related to the FCM simulation were discussed. Here, some choices had to be done, which created a number of constraints in the approach of this subject, as well as creating several possibilities for the treatment and interpretation of the data. Constraints are an ordinary step in modeling processes. The numeric approximation of the literal gradations transforms qualitative data in numeric ones, which after processed has to be transformed again in some kind of qualitative information (fuzzy values). FCM simulation has to take some numeric value to operate models of real situations making possible, in this way, the data computation. Despite of that, it is intrinsic to the simulation process, and it causes limitations to the information. In order to minimize the influence of numeric constraints the software allows selecting several different numeric parameters. Thus, the user can test and choose numeric approximations that he/she considers the best one. The next chapter will try numeric values out to aim at the best numeric approximation. Also, some simulations will be performed to find out the "hidden" relations among the concepts.

Chapter 8

TESTS AND RESULTS

8.1 Introduction

This chapter presents the tests and results that were obtained with the application of the implementation previously proposed. Several tests and calculations were performed to figure out the numeric tendencies of the system and how it could influence the interpretation of the results. Such tests implied different categories of results, some only related to numeric aspects and others related to the psychological interpretation of the concepts interaction. The latter will be analyzed separately in the next chapter.

Statistical calculations have been carried out here in order to find out general aspects of the data collection: experts' response profile, influence of a concept in the system, and the General Average Matrix. The analysis of those data brings out some qualitative aspects of the responses, which are important in the definition of the further steps of this research.

The numeric tendencies have been analyzed with the aim of knowing how different sets of numeric equivalents and different threshold functions affect the system responses. Some tests are performed combining several numeric possibilities. The results have indicated a somewhat independence of the system behavior in relation to the choice of numeric equivalents and threshold functions. In each case the system's general responses keep a kind of pattern profile of even varying numeric attributes. This conclusion is important because it provides much confidence in the interpretation of the interrelation among the concepts.

8.2 Exploratory Analysis of the Data

This item presents an analysis of the data collected, some general statistics, and information about the influence of each concept on the whole system. It accounts information about the experts' responses showing a profile of the data collected. Some statistical parameters are calculated showing features of the data. Considerations about the "energy" of the concepts are computed. The "energy" of a concept shows how much a concept influences positively/negatively the others, and how much a concept is influenced positively/negatively by others.

8.2.1 Data Collection

The questionnaire layout is shown in Appendix A. Twelve questionnaires were handed over but just nine returned answered. These questionnaires were tabulated and they are shown in Tables B1, B3, B5, B7, B9, B11, B13, B15, and B17 in Appendix B. Based on these data collection some general statistics of the responses were calculated. The frequencies of occurrence of each gradation in each expert's answered questionnaire were computed and the obtained results are shown in Tables B2, B4, B6, B8, B10, B12, B14, B16, and B18 in Appendix B. In these last tables the column on the left side, which is labelled "ACTIVATING", shows a computation of each gradation per line in the matrix of answers. In FCMs the computation per line means the capacity of the concept in the activation or causation of the others. This "causation", in the FCM graph, is represented as an arrow that leaves the node (concept) towards another node. The column on the right side, which is labelled "BEING ACTIVED", shows a computation of each gradation per column in each expert's whole matrix. In FCMs the computation per column means how much a concept receives influence of the others. In the FCM graph, it is represented as arrows getting to a node.

Figure 8.1 places together the profile of answers of each expert. The occurrence of each gradation is organized in a histogram fashion, which comparatively shows part of the results collected in Tables B2, B4, B6, B8, B10, B12, B14, B16, and B18. Based on this figure, it is possible to realize that the experts 4, 5 and 8 answered more than 50% of *NC* (*Não Causa* – no cause) of the total of answers, and that the amount of *DP* (*Diminui Pouco* - little decrease) corresponds to the least amount of the answers for all experts. Other information could be extracted from this figure but these ones are more relevant at this moment.

8.2.2 General Statistics of the Data

Table 8.1 shows the “General Percentage Matrix”, which computes the total of the experts’ answers. It can be verified that the gradation with the highest average percentage value is the number of *NC* – 43.2% with a standard deviation of 28.3%. It is followed by the number of *A*s (*Aumenta* – increase) – 16.6% with a standard deviation of 10.4%; by the number of *AM*s (*Aumenta Muito* – much increase) – 16.1% with a standard deviation of 12.3%; and by the number of *DM*s (*Diminui Muito* – much decrease) with 9.4% with a standard deviation of 7.3%. It can also be verified that the gradation *DM*, *D* and *DP* are smaller than *AM*, *A* and *AP*. This fact seems to demonstrate that it is more difficult to perceive the decrease of something than the increase. This kind of analysis is just to allow a qualitative notion about the gradations and how the experts deal with them.

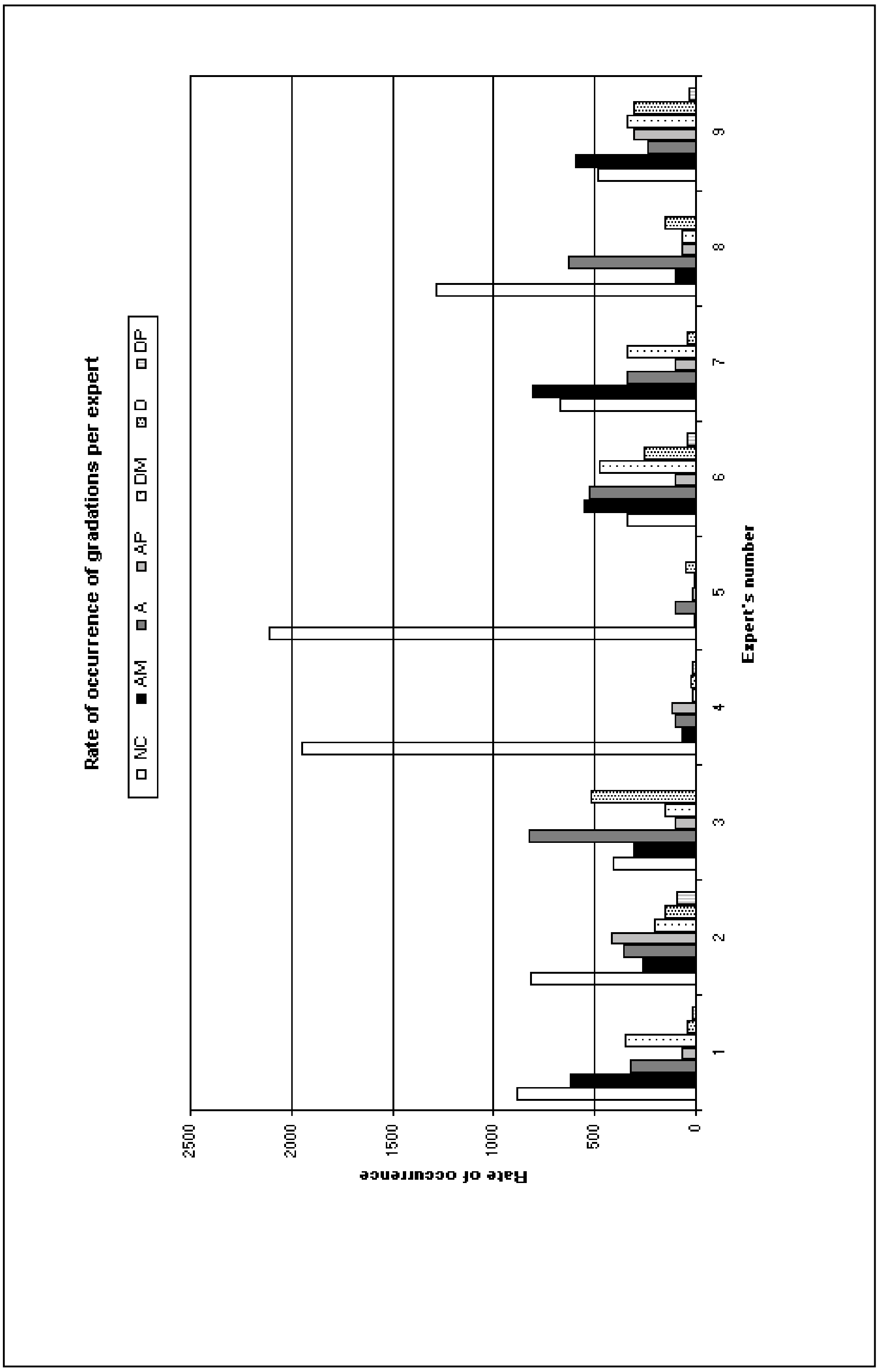

Figure 8.1 – Profile of experts' responses.

The data obtained in Table 8.1 were ordered and shown again in Table 8.2 and Table 8.3. Each column corresponds to the percent occurrence of each gradation and it is organized in increasing order. Each value brings together, on the left side, the corresponding concept number. It can be verified that in "ACTIVATING" (Table 8.2) the concept with the greatest occurrence of *NC* is the concept number 38 (*Organization*), with the highest occurrence of *AM* is the concept number 27 (*To be accepted*) as also the concept number 19 (*Desire for power / domination*) and a little bit less the concept 28 (*To be important / worthy*), with the highest occurrence of *A* is the concept number 4 (*Anger*), with the highest occurrence of *AP* is the concept number 20 (*Desire to attract attention*), with the highest occurrence of *DM* is the concept number 33 (*Inertia to change/to start*), with the highest occurrence of *D* is the concept number 10 (*Shame*), and with the highest occurrence of *DP* is the concept number 13 (*Introversion*).

Similarly, in Table 8.3 each column shows, in increasing order, the percentage of occurrence of each gradation. Also, each value brings together, on the left side, the corresponding concept number. This table represents how much a concept is activated by the others. It can be verified that in "BEING ACTIVATED" the concept with the highest occurrence of *NC* is the concept number 8 (*Jealousy*), with the highest occurrence of *AM* is the concept number 47 (*Stress*), with the highest occurrence of *A* is the concept number 34 (*To act*), with the highest occurrence of *AP* is the concept number 20 (*Desire to attract attention*), with the highest occurrence of *DM*, *D*, and *DP* coincidentally is the concept number 33 (*Inertia to change/to start*).

Table 8.1 – General Percentage Matrix per gradations.

General Percentage Matrix

Occurrence of Answers Concerning Activation Characteristics:

Concept	A C T I V A T I N G							Concept	B E I N G A C T I V A T E D						
	NC	AM	A	AP	DM	D	DP		NC	AM	A	AP	DM	D	DP
1	46.8	13.9	22.5	6.5	3.5	6.3	.7	1	45.6	20.8	15.5	7.9	7.2	2.3	.7
2	37.5	12.0	16.0	6.9	14.8	11.8	.9	2	47.7	14.4	13.9	5.3	10.0	6.9	1.9
3	36.8	16.2	16.7	3.2	13.7	12.5	.9	3	47.7	10.6	16.4	8.8	9.3	5.8	1.4
4	35.6	16.2	23.4	5.8	4.6	12.3	2.1	4	53.5	12.7	13.2	8.6	6.3	4.9	.9
5	55.1	8.1	13.7	6.5	6.7	9.7	.2	5	61.6	11.3	13.4	5.1	4.2	3.7	.7
6	39.6	10.2	14.1	7.2	12.3	15.3	1.4	6	61.6	5.8	14.4	7.9	5.6	3.9	.9
7	34.0	17.8	21.3	7.9	6.9	11.1	.9	7	68.5	6.0	9.0	8.8	2.5	3.9	1.2
8	31.3	18.3	21.3	7.2	8.6	12.5	.9	8	71.3	5.3	9.7	7.4	2.5	2.5	1.2
9	36.1	10.6	18.8	6.0	12.3	14.6	1.6	9	60.6	14.1	13.4	5.3	3.0	2.5	.9
10	37.7	9.5	14.1	6.5	14.4	16.4	1.4	10	63.4	6.3	10.9	9.3	6.0	1.9	2.3
11	49.5	16.2	16.2	4.2	8.3	4.9	.7	11	50.0	14.6	12.5	4.2	11.6	6.5	.7
12	30.6	10.0	20.6	10.4	12.0	14.6	1.9	12	45.8	19.2	11.3	6.7	9.5	5.1	2.3
13	45.8	5.8	11.3	9.0	10.6	14.1	3.2	13	55.8	12.5	10.6	3.2	9.3	7.6	.9
14	45.8	15.7	19.2	3.9	6.0	8.8	.5	14	45.1	18.3	13.4	4.4	10.9	6.5	1.4
15	44.7	16.7	18.3	8.6	4.2	7.2	.5	15	43.5	18.1	21.5	4.9	5.6	6.3	.2
16	50.0	13.9	18.5	7.2	2.5	6.3	1.6	16	55.3	15.7	15.7	3.9	2.5	6.7	.0
17	43.1	22.7	18.8	6.5	4.4	4.4	.2	17	28.2	24.5	25.7	6.0	8.1	6.5	.9
18	46.8	11.1	22.0	5.1	3.5	10.9	.7	18	38.7	16.9	20.6	6.3	9.7	7.4	.5
19	35.2	26.2	18.3	8.3	6.9	4.4	.7	19	44.4	11.1	16.7	8.6	9.5	9.0	.7
20	41.9	13.9	21.5	13.9	2.3	4.9	1.6	20	44.2	10.9	24.3	11.8	4.9	3.9	.0
21	49.1	12.5	21.5	7.4	4.9	4.4	.2	21	35.9	16.2	22.9	9.5	6.3	8.3	.9
22	34.3	18.8	20.6	8.1	7.2	9.7	1.4	22	66.2	10.0	8.1	7.4	4.4	3.7	.2
23	45.4	21.8	14.8	6.0	6.3	5.3	.5	23	27.1	28.2	24.1	4.9	7.6	7.4	.7
24	52.1	16.9	11.1	6.3	9.0	3.7	.9	24	49.8	10.2	15.0	4.9	7.6	10.2	2.3
25	43.3	19.9	20.8	4.2	5.6	5.1	1.2	25	43.1	17.4	22.5	7.4	4.4	5.1	.2
26	39.1	16.4	11.1	4.2	16.2	12.0	.9	26	48.1	16.7	10.4	6.7	10.6	6.3	1.2
27	38.9	26.2	13.9	4.2	12.0	3.7	1.2	27	37.0	17.8	22.2	6.3	10.4	6.3	.0
28	41.7	25.2	14.6	5.3	10.0	3.0	.2	28	30.6	22.0	25.9	5.6	10.2	5.3	.5
29	42.4	20.8	15.7	3.0	13.7	3.7	.7	29	25.2	22.5	19.2	5.8	14.6	11.3	1.4
30	45.1	18.8	15.0	6.3	11.6	2.3	.9	30	27.5	22.7	17.8	5.6	15.0	10.0	1.4
31	40.0	17.4	16.9	6.3	12.5	6.3	.7	31	52.8	10.2	9.7	8.8	10.0	7.2	1.4
32	45.1	19.9	18.1	4.2	5.6	6.3	.9	32	27.1	22.7	24.8	7.6	8.8	7.6	1.4
33	44.2	8.3	11.8	3.7	23.8	7.4	.7	33	32.6	10.9	8.6	2.8	25.5	17.1	2.5
34	48.4	19.9	12.5	5.8	7.6	5.3	.5	34	21.5	28.0	26.4	4.2	10.2	8.3	1.4
35	42.6	14.1	9.0	4.4	16.0	13.0	.9	35	46.1	13.0	7.9	3.9	18.1	10.2	.9
36	45.4	20.6	14.8	5.3	8.3	4.4	1.2	36	25.5	28.0	21.8	5.8	8.1	9.0	1.9
37	51.2	12.5	18.8	7.4	4.2	4.6	1.4	37	31.9	19.4	22.0	6.7	11.1	8.3	.5
38	60.6	10.4	14.4	6.0	4.6	2.1	1.9	38	44.2	14.6	18.8	5.1	6.9	9.0	1.4
39	47.2	15.0	20.4	3.7	6.9	4.4	2.3	39	28.7	17.8	19.9	3.7	15.3	12.7	1.9
40	51.6	16.0	16.9	2.1	8.3	3.2	1.9	40	29.2	23.8	16.0	5.6	16.9	7.6	.9
41	44.7	11.6	12.3	9.7	15.7	6.0	.0	41	33.8	15.7	16.4	7.4	14.6	11.1	.9
42	45.8	21.8	14.1	3.5	11.8	3.0	.0	42	30.3	13.9	17.8	4.2	16.2	16.2	1.4
43	47.5	17.1	16.4	8.1	6.0	3.9	.9	43	27.3	18.1	23.8	3.9	13.7	12.0	1.2
44	44.9	19.4	17.1	8.1	6.7	1.9	1.9	44	37.7	17.8	16.9	4.9	13.9	7.4	1.4
45	37.5	12.7	19.9	9.7	12.5	6.5	1.2	45	49.1	10.4	12.3	8.6	10.2	9.3	.2
46	36.1	20.6	11.1	3.2	19.9	8.6	.5	46	59.3	9.7	13.0	6.3	4.6	7.2	.0
47	51.2	13.2	6.3	4.6	14.1	9.7	.9	47	30.1	29.4	16.0	6.0	10.6	7.4	.5
48	35.4	19.0	20.8	9.0	12.3	3.2	.2	48	44.2	15.5	14.8	6.9	8.1	10.0	.5
Average															
% :	43.2	16.1	16.6	6.3	9.4	7.4	1.0	% :	43.2	16.1	16.6	6.3	9.4	7.4	1.0
StD%	28.3	12.3	10.4	5.7	7.3	7.1	1.3	StD%	28.3	12.3	10.4	5.7	7.3	7.1	1.3

Table 8.2 - General Percentage Matrix per gradations “Activating”.

General Percentage Matrix

Occurrence of Ordered Answers Concerning "Activating" Characteristics:

A C T I V A T I N G													
Conc.	NC	Conc.	AM	Conc.	A	Conc.	AP	Conc.	DM	Conc.	D	Conc.	DP
12>	30.6	13>	5.8	47>	6.3	40>	2.1	20>	2.3	44>	1.9	41>	.0
8>	31.3	5>	8.1	35>	9.0	29>	3.0	16>	2.5	38>	2.1	42>	.0
7>	34.0	33>	8.3	24>	11.1	3>	3.2	1>	3.5	30>	2.3	5>	.2
22>	34.3	10>	9.5	26>	11.1	46>	3.2	18>	3.5	28>	3.0	17>	.2
19>	35.2	12>	10.0	46>	11.1	42>	3.5	15>	4.2	42>	3.0	21>	.2
48>	35.4	6>	10.2	13>	11.3	33>	3.7	37>	4.2	40>	3.2	28>	.2
4>	35.6	38>	10.4	33>	11.8	39>	3.7	17>	4.4	48>	3.2	48>	.2
9>	36.1	9>	10.6	41>	12.3	14>	3.9	4>	4.6	24>	3.7	14>	.5
46>	36.1	18>	11.1	34>	12.5	11>	4.2	38>	4.6	27>	3.7	15>	.5
3>	36.8	41>	11.6	5>	13.7	25>	4.2	21>	4.9	29>	3.7	23>	.5
2>	37.5	2>	12.0	27>	13.9	26>	4.2	25>	5.6	43>	3.9	34>	.5
45>	37.5	21>	12.5	6>	14.1	27>	4.2	32>	5.6	17>	4.4	46>	.5
10>	37.7	37>	12.5	10>	14.1	32>	4.2	14>	6.0	19>	4.4	1>	.7
27>	38.9	45>	12.7	42>	14.1	35>	4.4	43>	6.0	21>	4.4	11>	.7
26>	39.1	47>	13.2	38>	14.4	47>	4.6	23>	6.3	36>	4.4	18>	.7
6>	39.6	1>	13.9	28>	14.6	18>	5.1	5>	6.7	39>	4.4	19>	.7
31>	40.0	16>	13.9	23>	14.8	28>	5.3	44>	6.7	37>	4.6	29>	.7
28>	41.7	20>	13.9	36>	14.8	36>	5.3	7>	6.9	11>	4.9	31>	.7
20>	41.9	35>	14.1	30>	15.0	4>	5.8	19>	6.9	20>	4.9	33>	.7
29>	42.4	39>	15.0	29>	15.7	34>	5.8	39>	6.9	25>	5.1	2>	.9
35>	42.6	14>	15.7	2>	16.0	9>	6.0	22>	7.2	23>	5.3	3>	.9
17>	43.1	40>	16.0	11>	16.2	23>	6.0	34>	7.6	34>	5.3	7>	.9
25>	43.3	3>	16.2	43>	16.4	38>	6.0	11>	8.3	41>	6.0	8>	.9
33>	44.2	4>	16.2	3>	16.7	24>	6.3	36>	8.3	1>	6.3	24>	.9
15>	44.7	11>	16.2	31>	16.9	30>	6.3	40>	8.3	16>	6.3	26>	.9
41>	44.7	26>	16.4	40>	16.9	31>	6.3	8>	8.6	31>	6.3	30>	.9
44>	44.9	15>	16.7	44>	17.1	1>	6.5	24>	9.0	32>	6.3	32>	.9
30>	45.1	24>	16.9	32>	18.1	5>	6.5	28>	10.0	45>	6.5	35>	.9
32>	45.1	43>	17.1	15>	18.3	10>	6.5	13>	10.6	15>	7.2	43>	.9
23>	45.4	31>	17.4	19>	18.3	17>	6.5	30>	11.6	33>	7.4	47>	.9
36>	45.4	7>	17.8	16>	18.5	2>	6.9	42>	11.8	46>	8.6	25>	1.2
13>	45.8	8>	18.3	9>	18.8	6>	7.2	12>	12.0	14>	8.8	27>	1.2
14>	45.8	22>	18.8	17>	18.8	8>	7.2	27>	12.0	5>	9.7	36>	1.2
42>	45.8	30>	18.8	37>	18.8	16>	7.2	6>	12.3	22>	9.7	45>	1.2
1>	46.8	48>	19.0	14>	19.2	21>	7.4	9>	12.3	47>	9.7	6>	1.4
18>	46.8	44>	19.4	45>	19.9	37>	7.4	48>	12.3	18>	10.9	10>	1.4
39>	47.2	25>	19.9	39>	20.4	7>	7.9	31>	12.5	7>	11.1	22>	1.4
43>	47.5	32>	19.9	12>	20.6	22>	8.1	45>	12.5	2>	11.8	37>	1.4
34>	48.4	34>	19.9	22>	20.6	43>	8.1	3>	13.7	26>	12.0	9>	1.6
21>	49.1	36>	20.6	25>	20.8	44>	8.1	29>	13.7	4>	12.3	16>	1.6
11>	49.5	46>	20.6	48>	20.8	19>	8.3	47>	14.1	3>	12.5	20>	1.6
16>	50.0	29>	20.8	7>	21.3	15>	8.6	10>	14.4	8>	12.5	12>	1.9
37>	51.2	23>	21.8	8>	21.3	13>	9.0	2>	14.8	35>	13.0	38>	1.9
47>	51.2	42>	21.8	20>	21.5	48>	9.0	41>	15.7	13>	14.1	40>	1.9
40>	51.6	17>	22.7	21>	21.5	41>	9.7	35>	16.0	9>	14.6	44>	1.9
24>	52.1	28>	25.2	18>	22.0	45>	9.7	26>	16.2	12>	14.6	4>	2.1
5>	55.1	19>	26.2	1>	22.5	12>	10.4	46>	19.9	6>	15.3	39>	2.3
38>	60.6	27>	26.2	4>	23.4	20>	13.9	33>	23.8	10>	16.4	13>	3.2

Table 8.3 -- General Percentage Matrix per gradations “Being Activated”.

General Percentage Matrix

Occurrence of Ordered Answers Concerning "Being Actività" Characteristics:

B E I N G A C T I V A T E D													
Conc.	NC	Conc.	AM	Conc.	A	Conc.	AP	Conc.	DM	Conc.	D	Conc.	DP
34>	21.5	8>	5.3	35>	7.9	33>	2.8	7>	2.5	10>	1.9	16>	.0
29>	25.2	6>	5.8	22>	8.1	13>	3.2	8>	2.5	1>	2.3	20>	.0
36>	25.5	7>	6.0	33>	8.6	39>	3.7	16>	2.5	8>	2.5	27>	.0
23>	27.1	10>	6.3	7>	9.0	16>	3.9	9>	3.0	9>	2.5	46>	.0
32>	27.1	46>	9.7	8>	9.7	35>	3.9	5>	4.2	5>	3.7	15>	.2
43>	27.3	22>	10.0	31>	9.7	43>	3.9	22>	4.4	22>	3.7	22>	.2
30>	27.5	24>	10.2	26>	10.4	11>	4.2	25>	4.4	6>	3.9	25>	.2
17>	28.2	31>	10.2	13>	10.6	34>	4.2	46>	4.6	7>	3.9	45>	.2
39>	28.7	45>	10.4	10>	10.9	42>	4.2	20>	4.9	20>	3.9	18>	.5
40>	29.2	3>	10.6	12>	11.3	14>	4.4	6>	5.6	4>	4.9	28>	.5
47>	30.1	20>	10.9	45>	12.3	15>	4.9	15>	5.6	12>	5.1	37>	.5
42>	30.3	33>	10.9	11>	12.5	23>	4.9	10>	6.0	25>	5.1	47>	.5
28>	30.6	19>	11.1	46>	13.0	24>	4.9	4>	6.3	28>	5.3	48>	.5
37>	31.9	5>	11.3	4>	13.2	44>	4.9	21>	6.3	3>	5.8	1>	.7
33>	32.6	13>	12.5	5>	13.4	5>	5.1	38>	6.9	15>	6.3	5>	.7
41>	33.8	4>	12.7	9>	13.4	38>	5.1	1>	7.2	26>	6.3	11>	.7
21>	35.9	35>	13.0	14>	13.4	2>	5.3	23>	7.6	27>	6.3	19>	.7
27>	37.0	42>	13.9	2>	13.9	9>	5.3	24>	7.6	11>	6.5	23>	.7
44>	37.7	9>	14.1	6>	14.4	28>	5.6	17>	8.1	14>	6.5	4>	.9
18>	38.7	2>	14.4	48>	14.8	30>	5.6	36>	8.1	17>	6.5	6>	.9
25>	43.1	11>	14.6	24>	15.0	40>	5.6	48>	8.1	16>	6.7	9>	.9
15>	43.5	38>	14.6	1>	15.5	29>	5.8	32>	8.8	2>	6.9	13>	.9
20>	44.2	48>	15.5	16>	15.7	36>	5.8	3>	9.3	31>	7.2	17>	.9
38>	44.2	16>	15.7	40>	16.0	17>	6.0	13>	9.3	46>	7.2	21>	.9
48>	44.2	41>	15.7	47>	16.0	47>	6.0	12>	9.5	18>	7.4	35>	.9
19>	44.4	21>	16.2	3>	16.4	18>	6.3	19>	9.5	23>	7.4	40>	.9
14>	45.1	26>	16.7	41>	16.4	27>	6.3	18>	9.7	44>	7.4	41>	.9
1>	45.6	18>	16.9	19>	16.7	46>	6.3	2>	10.0	47>	7.4	7>	1.2
12>	45.8	25>	17.4	44>	16.9	12>	6.7	31>	10.0	13>	7.6	8>	1.2
35>	46.1	27>	17.8	30>	17.8	26>	6.7	28>	10.2	32>	7.6	26>	1.2
2>	47.7	39>	17.8	42>	17.8	37>	6.7	34>	10.2	40>	7.6	43>	1.2
3>	47.7	44>	17.8	38>	18.8	48>	6.9	45>	10.2	21>	8.3	3>	1.4
26>	48.1	15>	18.1	29>	19.2	8>	7.4	27>	10.4	34>	8.3	14>	1.4
45>	49.1	43>	18.1	39>	19.9	22>	7.4	26>	10.6	37>	8.3	29>	1.4
24>	49.8	14>	18.3	18>	20.6	25>	7.4	47>	10.6	19>	9.0	30>	1.4
11>	50.0	12>	19.2	15>	21.5	41>	7.4	14>	10.9	36>	9.0	31>	1.4
31>	52.8	37>	19.4	36>	21.8	32>	7.6	37>	11.1	38>	9.0	32>	1.4
4>	53.5	1>	20.8	37>	22.0	1>	7.9	11>	11.6	45>	9.3	34>	1.4
16>	55.3	28>	22.0	27>	22.2	6>	7.9	43>	13.7	30>	10.0	38>	1.4
13>	55.8	29>	22.5	25>	22.5	4>	8.6	44>	13.9	48>	10.0	42>	1.4
46>	59.3	30>	22.7	21>	22.9	19>	8.6	29>	14.6	24>	10.2	44>	1.4
9>	60.6	32>	22.7	43>	23.8	45>	8.6	41>	14.6	35>	10.2	2>	1.9
5>	61.6	40>	23.8	23>	24.1	3>	8.8	30>	15.0	41>	11.1	36>	1.9
6>	61.6	17>	24.5	20>	24.3	7>	8.8	39>	15.3	29>	11.3	39>	1.9
10>	63.4	34>	28.0	32>	24.8	31>	8.8	42>	16.2	43>	12.0	10>	2.3
22>	66.2	36>	28.0	17>	25.7	10>	9.3	40>	16.9	39>	12.7	12>	2.3
7>	68.5	23>	28.2	28>	25.9	21>	9.5	35>	18.1	42>	16.2	24>	2.3
8>	71.3	47>	29.4	34>	26.4	20>	11.8	33>	25.5	33>	17.1	33>	2.5

The frequency of occurrence of the gradations is independent of the choice of numeric equivalents. These parameters give an idea in relation to the influence of each concept in the whole net. This analysis does not consider the weight given by numeric equivalents; it has just accounted for the frequency of occurrence of each single gradation. The next item has accounted for the weight of positive gradations and negative gradations to find out the "energy" of each concept.

8.2.3 Energy of a Concept

In the last chapter, item 7.4.3 explains about the "energy a concept". Equations 7.3, 7.4, 7.5 and 7.6 defined the "energy" factors. The computation of the data collected generated the values of the parameters $N^{l}_{AM}, N^{l}_{A}, N^{l}_{AP}, N^{l}_{DM}, N^{l}_{D}$, and N^{l}_{DP}. Table 8.2 (ACTIVATING), on the left side, shows these parameters in percent fashion. These percent values can be transformed in simple numbers multiplying $\frac{48}{100}$. The same way was used to obtain the values of $N^{c}_{AM}, N^{c}_{A}, N^{c}_{AP}, N^{c}_{DM}, N^{c}_{D}$, and N^{c}_{DP} from the data in Table 8.3 (BEING ACTIVATED), on the right side.

The obtained results represent the "Activation Energy". In Appendix E the Tables E3, E6, E9, E12 and E15 show the "Activation Energy" corresponding to *linear, golden ratio, reverse golden ratio, square ratio* and *exponential* ratio, respectively. In those tables, the value of energy is ordered and the corresponding concept is brought together on the left. Table 8.4 summarizes the most meaningful data.

Table 8.4– The most energetic concepts.

	The most *energetic* concepts			
Numeric Equivalent	Max. Activ+	**Max. Activ-**	**Max. BeAct+**	**Max. BeAct-**
Linear	19) Desire for power/domination 17) Desire for achievement	33) Inertia to change/to start 10) Shame	34) To act 23) Motivation	33) Inertia to change/ to start 42) Confidence in the group
Golden ratio	Ibidem as linear ratio	Ibidem as linear ratio	Ibidem as linear ratio	Ibidem as linear ratio
Reverse golden ratio	19) Desire for power/domination 27) To be accepted	33) Inertia to change/to start 46) Punishment	Ibidem as linear ratio	Ibidem as linear ratio
Square ratio	Ibidem as Reverse golden ratio	Ibidem as Reverse golden ratio	Ibidem as linear ratio	Ibidem as linear ratio
Exponential ratio	Ibidem as linear ratio	Ibidem as linear ratio	Ibidem as linear ratio	Ibidem as linear ratio

Table 8.4 illustrates concepts that presented the most “energetic concepts” in a net of concepts that was proposed. It can be inferred that the concepts *Desire for power/domination, Desire for achievement,* and *To be accepted* have more capacity to activate (increasing) the others. It can also be inferred that the concepts *Inertia to change/to start, Shame,* and *Punishment* have more capacity to inhibit (decreasing) the others. On the other hand, the concepts that are more influenced/activated in the increasing sense by the others are *To act,* and *Motivation*. And the concepts that are more influenced in the decreasing sense by the others are *Inertia to change/ to start,* and *Confidence in the group.* Then, such concepts are candidates to be activated/inhibit in further simulations. It is important to emphasize that even using different numeric equivalents the obtained results are close. Thus, in terms of energy, the weight provided by a numeric equivalent does not exert much influence on the behavior of the whole system.

8.2.4 General Average Matrix

Item 7.4.2 discussed the calculation of the General Average Matrix. The General Average Matrix aggregates all the data collection, which in this research will stand for the

FCM connection matrix. Therefore, it has an important role in the FCM technique. Each different set of numeric equivalents generates a different General Average Matrix. So, for the five set of numeric equivalents proposed by the software (see Table 7.5) five General Average Matrices are generated, which are shown in Appendix E, Tables E1 (*Linear*), E4 (*Golden ratio*), E7 (*Reverse Golden ratio*), E10 (*Square ratio*), and E13 (*Exponential ratio*). During the simulations, one of these matrices will be taken as the FCM connection matrix.

8.3 Analysis of Numeric Tendencies

The software allows several possibilities of combinations that are shown in Figure 8.2. Thus, if three values are taken (1, 0, -1) to each position of the input vector ($\mathbf{I_0}_{1\times 48}$), 5 different numeric equivalents, 5 different threshold functions, and clamped or no-clamped, then the total of combination becomes:

Total of combinations = $\left(3^{48}\right)\times 5\times 5\times 2 \cong 3.98\times 10^{24}$

Such total would imply an enormous number of possibilities. Several of these are inconsistent with real situations, and so they would not need to be tested. Even so, due to practical issues, just some few of those real possibilities are going to be tried out. Maybe, FCM associated with other techniques such as genetic algorithms would enable to test a greater number of combinations. But this is out of the scope of this present work.

Possibilities

- Activation
  - + 1
  - 0
  - - 1
- Numeric equivalent
  - Linear ratio
  - Golden ratio
  - Reverse golden ratio
  - Square ratio
  - Exponential ratio
- Threshold function
  - Regularization
  - Normalization
  - Trivalent
  - Septivalent
  - Sigmoid
- Clamped
  - Yes
  - No

Figure 8.2 – General scheme of numeric possibilities

8.3.1 Numerical Tests

Some tests are proposed aiming at evaluating the numeric tendencies or the numeric behaviors of this system. For preliminary tests the concept 19 was chosen (*Desire for domination / power*) as active (+1) because it has the highest "Activating" energy (see Table 8.4). Keeping this concept as active (+1), several combinations are tried, which are present in Table 8.5 from case 1 to case 29. The right column in this table shows the number of iterations when the system got steady.

A comparative analysis among the output vector $\mathbf{O}^{\mathbf{t}}_{\mathbf{1\times 48}}$ for different cases is shown from Figure 8.3 to Figure 8.5. In these comparisons the result obtained with the

Normalization threshold function was taken as reference. Figure 8.3 shows the comparative result among cases 1, 2, and 5 (continue values). Surveying this figure in terms of matching the results, it can be verified that a general coherence occurs among the signal of the numeric values. Only concepts 19 and 20 show a slight difference in terms of signal. The values obtained with Regularization and Sigmoid are closer than Normalization with each one. Also Normalization shows values surpassing the limits {-1, +1}.

Table 8.5- Tests with the concept 19 (*Desire for domination / power*) activated.

Test Number	Active Concept(s)	Numeric Equivalent	Threshold Function	Clamping	Convergence (# iterations)
1	19)=>+1	Linear	Regularization	Yes	21
2	19)=>+1	Linear	Normalization	Yes	16
3	19)=>+1	Linear	Trivalent	Yes	5
4	19)=>+1	Linear	Septivalent	Yes	9
5	19)=>+1	Linear	Sigmoid (λ=3.0)	Yes	22
6	19)=>+1	Linear	Normalization	No	16
7	19)=>+1	Golden ratio	Normalization	Yes	16
8	19)=>+1	Golden ratio	Septivalent	Yes	10
9	19)=>+1	Reverse golden ratio	Normalization	Yes	17
10	19)=>+1	Reverse golden ratio	Septivalent	Yes	8
11	19)=>+1	Square ratio	Normalization	Yes	16
12	19)=>+1	Square ratio	Septivalent	Yes	12
13	19)=>+1	Exponential	Normalization	Yes	16
14	19)=>+1	Exponential	Septivalent	Yes	12
15	19)=>+1	Golden ratio	Regularization	Yes	23
16	19)=>+1	Reverse Golden ratio	Regularization	Yes	22
17	19)=>+1	Square ratio	Regularization	Yes	20
18	19)=>+1	Exponential	Regularization	Yes	22
19	19)=>+1	Linear	Sigmoid (λ=5)	Yes	22
20	19)=>+1	Linear	Sigmoid (λ=1)	Yes	23
21	19)=>+1	Golden ratio	Sigmoid (λ=5)	Yes	23
22	19)=>+1	Reverse golden ratio	Sigmoid (λ=5)	Yes	21
23	19)=>+1	Square ratio	Sigmoid (λ=5)	Yes	21
24	19)=>+1	Exponential	Sigmoid (λ=5)	Yes	23
25	19)=>+1	Linear	Sigmoid (λ=5)	No	20
26	19)=>+1	Golden ratio	Trivalent	Yes	6
27	19)=>+1	Reverse golden ratio	Trivalent	Yes	6
28	19)=>+1	Square ratio	Trivalent	Yes	6
29	19)=>+1	Exponential	Trivalent	Yes	7

Figure 8.4 shows a comparative analysis of cases 2, 3 and 4. Trivalent and Septivalent threshold functions are discrete and they are compared with Normalization

(continual). The Trivalent function "filters" the values for only three numeric levels and Septivalent for seven numeric levels. In Figure 8.4 it can be verified that the Septivalent and Normalized outputs are closer than the Trivalent output. Differences between Septivalent and Normalized can specially be noticed in concepts 7, 8, 19, 20, 31 and 48 in terms of amplitude.

Figure 8.5 shows comparative results to the Sigmoid threshold function using different lambda values (λ=1, 3, 5) (cases 5, 19, 20). λ=5 represents higher levels in terms of the amplitude of the responses than the others. This fact means that higher lambda values very easily bring the system to saturation. In spite of the difference in amplitude of the values, the signal practically remains coherent for the same concept. Figure 8.6 is similar to Figure 8.3 but now with λ=5. In that figure it is possible to realize that the Normalization threshold function output gets closer to the Sigmoid threshold function than in Figure 8.3.

Figure 8.7 shows a comparative analysis between cases 2 and 6, Normalization threshold function clamped and no-clamped, respectively. In that case, with the concept 19 active it is easy to see that the result is practically identical. Also Figure 8.8 (cases 19 and 25) shows a comparison between sigmoid (λ=5) clamped and no-clamped. Also, it can be seen that there are no meaningful differences between the values of the same concept. In these cases higher values get closer than the lower ones. This fact can be associated to the saturation characteristics that sigmoid function expresses.

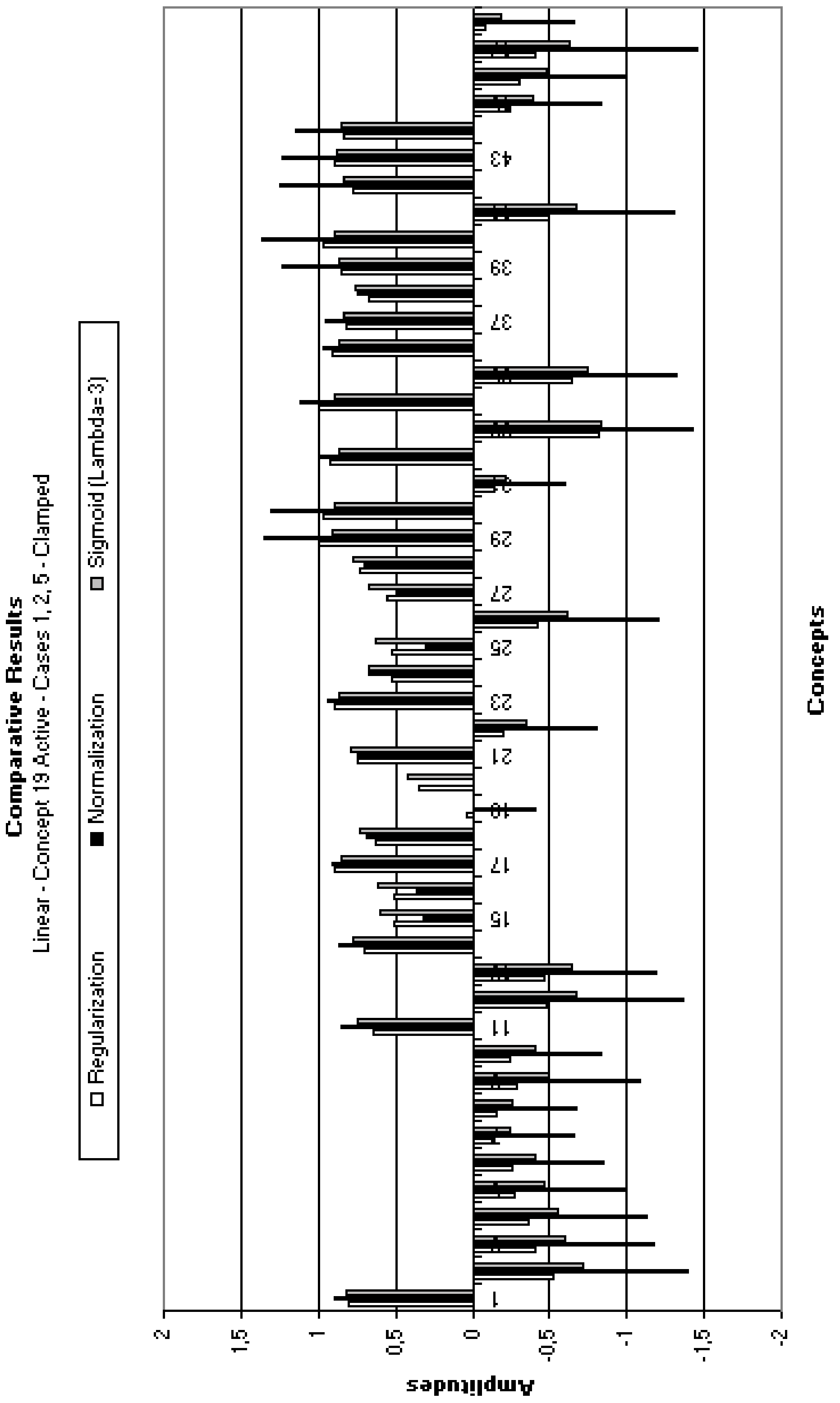

Figure 8.3 – Comparative results among Regularization, Normatization, and Sigmoid (Concept 19 = +1).

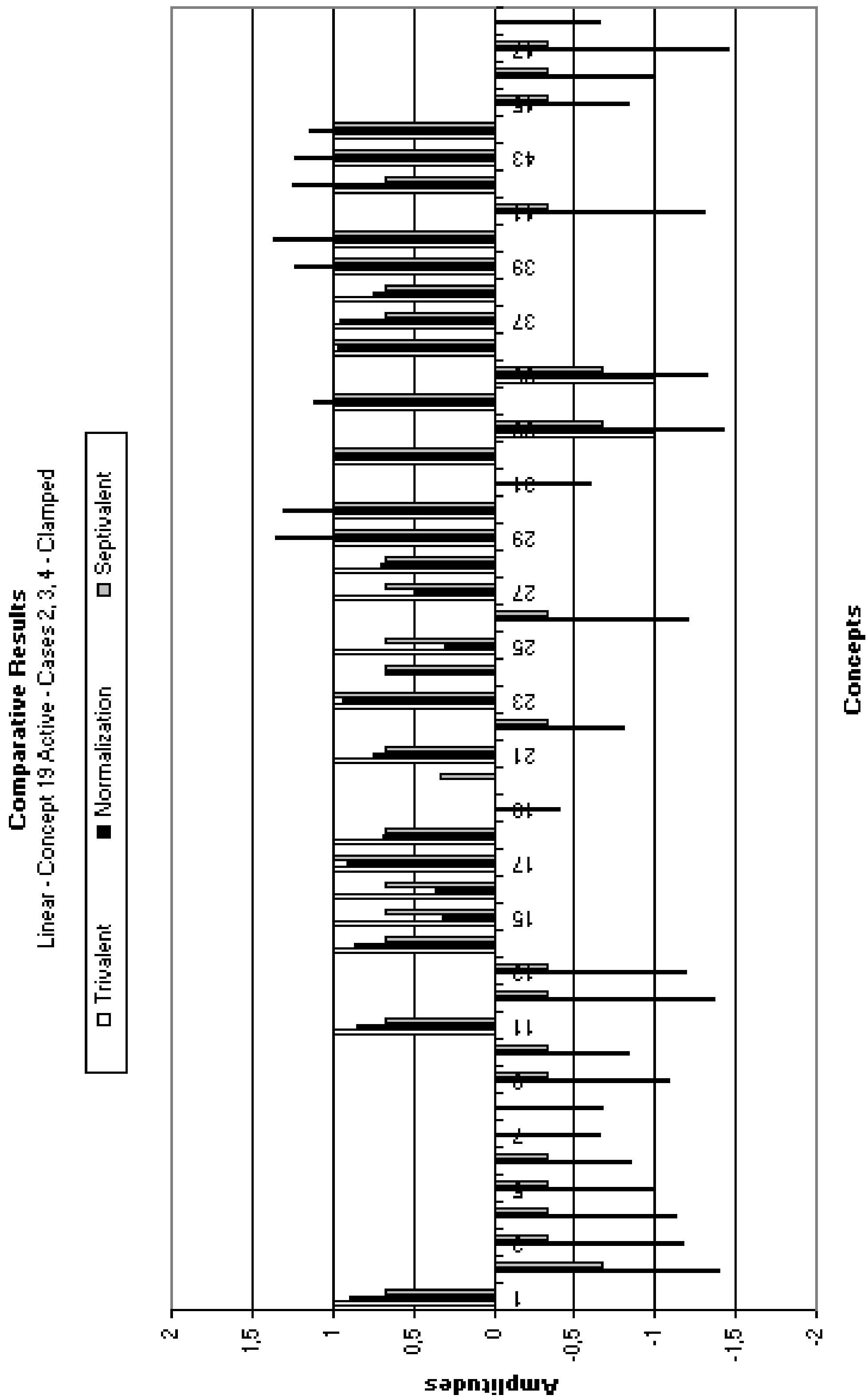

Figure 8.4 – Comparative results among Trivalent, Normatization, and Septivalent (Concept 19 = +1).

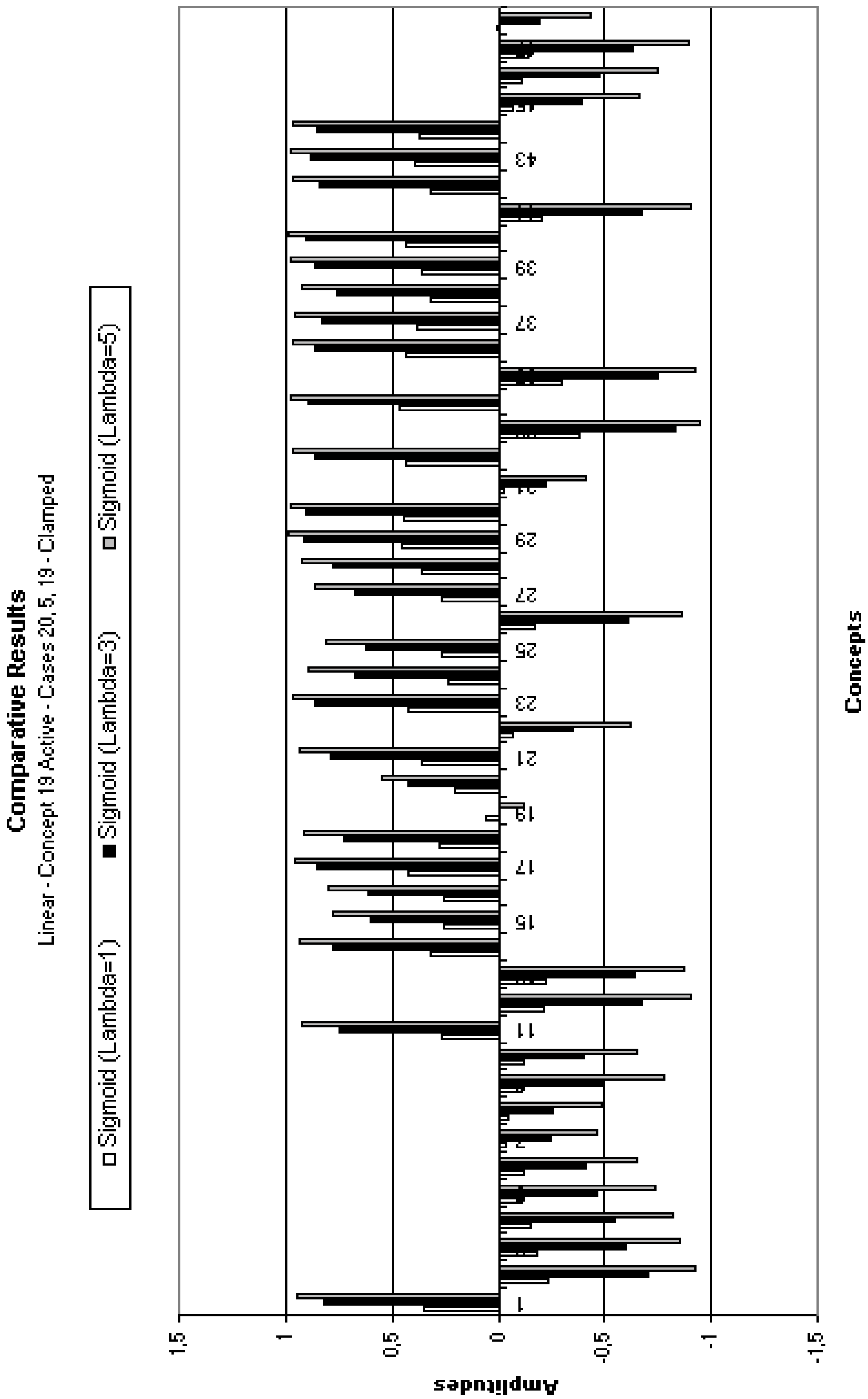

Figure 8.5 – Comparative results among Sigmoid with different lambdas (Concept 19 = +1).

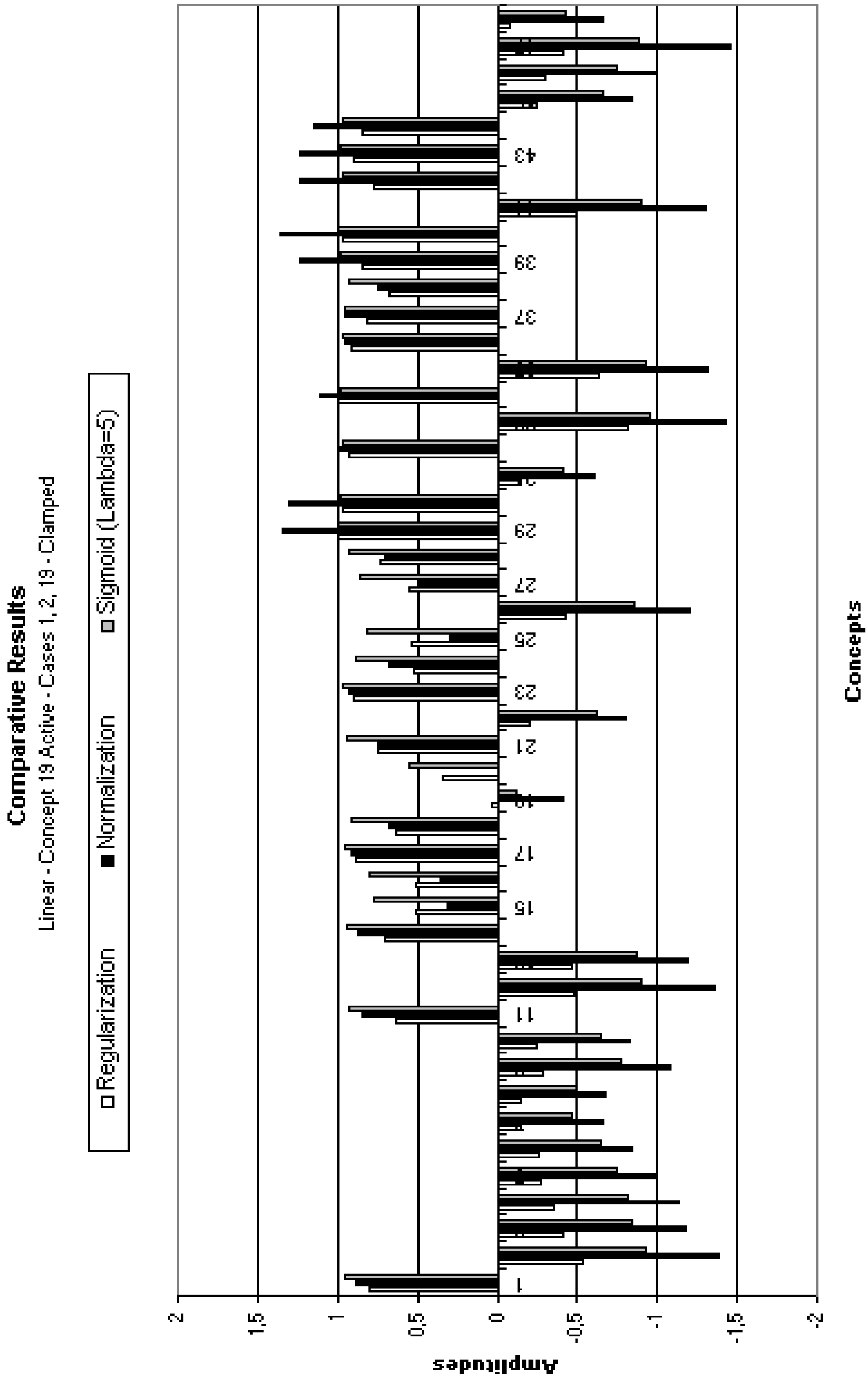

Figure 8.6 – Comparative results among Regularization, Normatization, and Sigmoid (Concept 19 = +1).

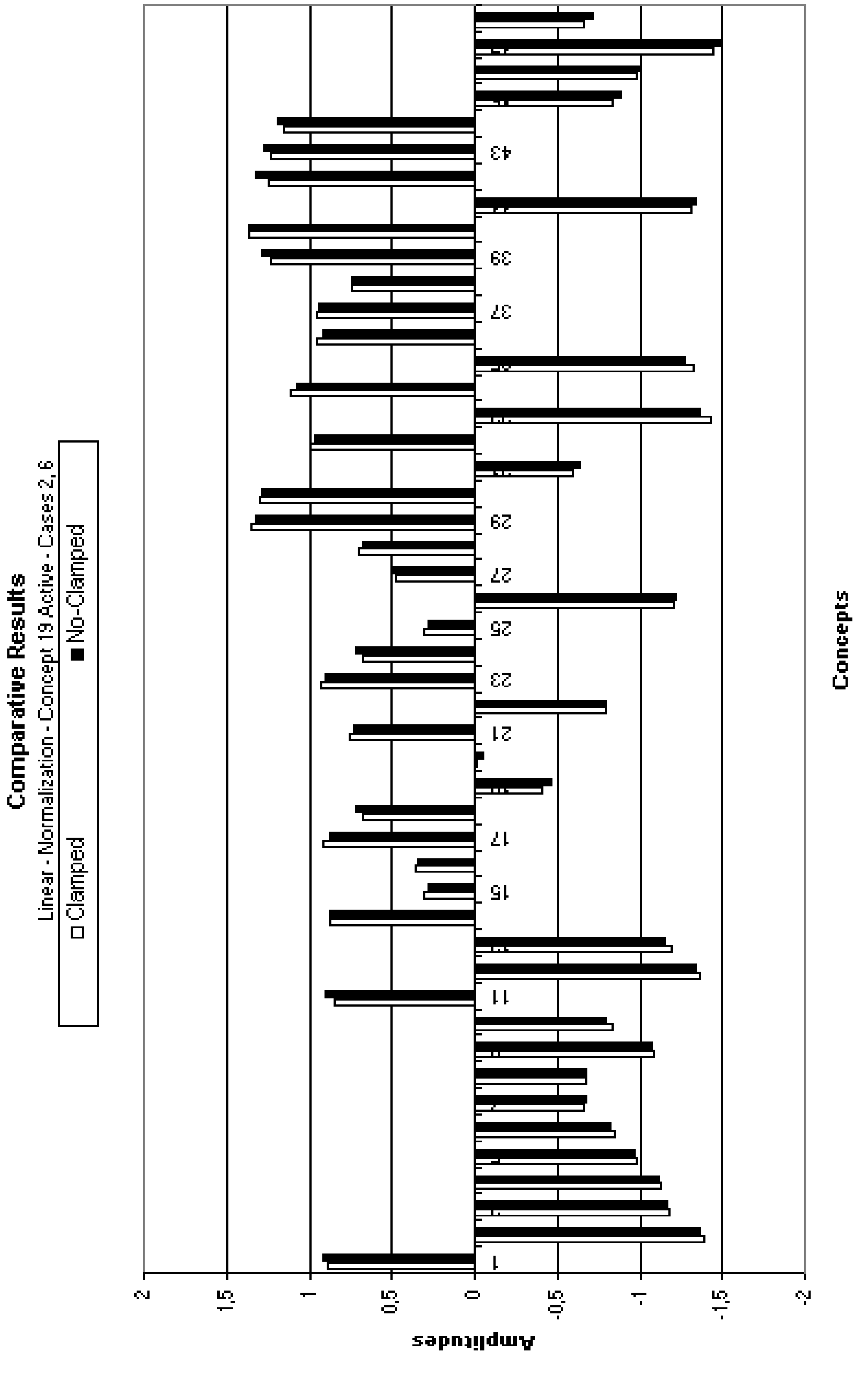

Figure 8.7 – Comparative results between Normatization clamped and no-clamped (Concept 19 = +1).

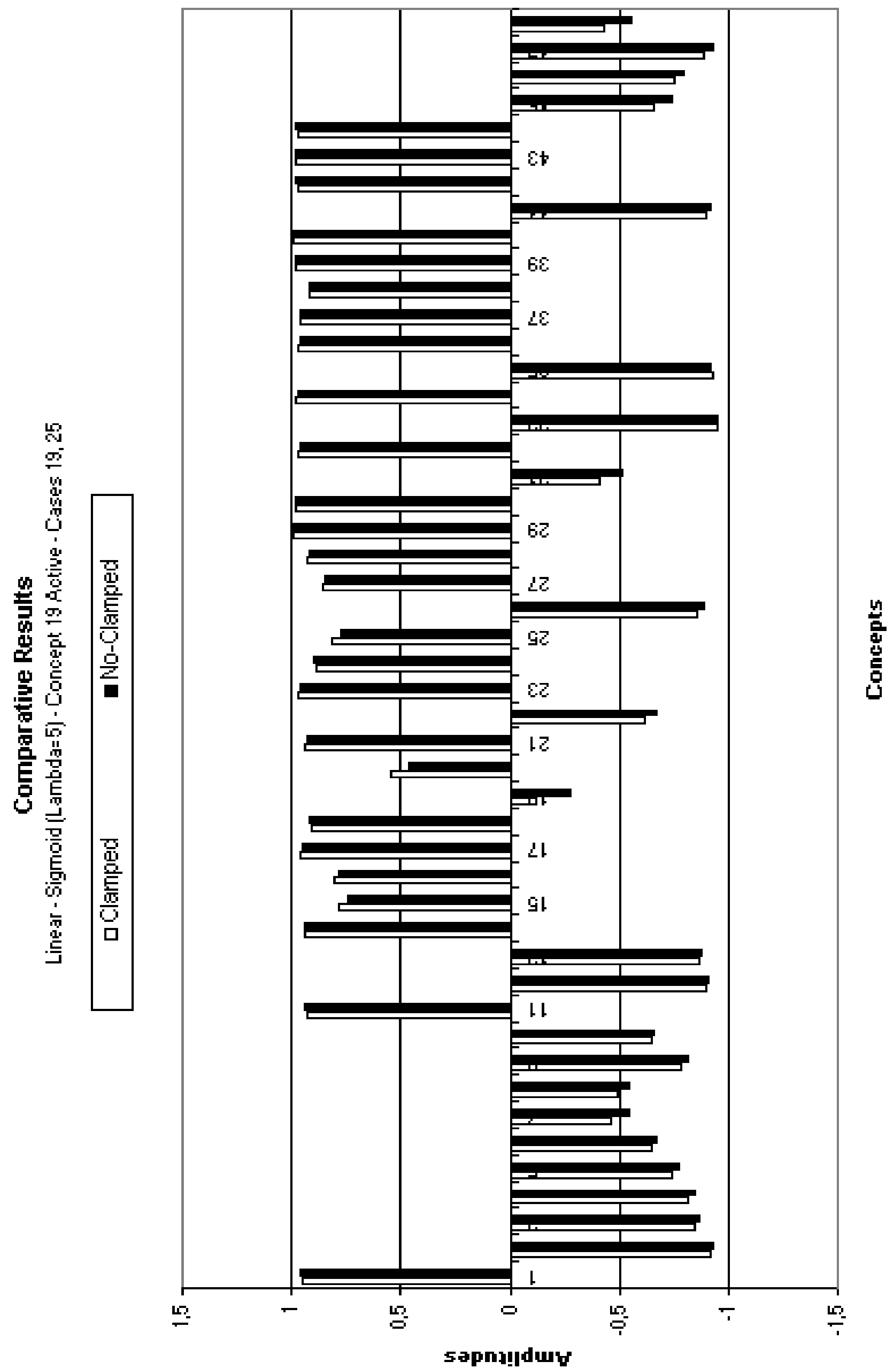

Figure 8.8 – Comparative results between Sigmoid clamped and no-clamped (Concept 19 = +1).

Three comparative analyses using the five different numeric equivalents (see Table 7.5) are shown in Figure 8.9 (cases 15, 16, 1, 17, 18), 8.10 (cases 2, 7, 9, 11, 13), and 8.11 (cases 19, 21, 22, 23, 24) for Regularization, Normalization, and Sigmoid threshold functions, respectively. In spite of the different numeric equivalents, these figures illustrate that there are no important differences among the values, and higher values are still closer than the lower ones. Therefore, for these continual values the choice of an equivalent numeric does not imply that significant differences in terms of activation for each concept.

Table 8.6 presents more 36 cases with the activation of the concepts 33 (*Inertia to change/ to start*) and 13 (*Introversion*). These cases will be analyzed further. Tables 8.7, 8.8 and 8.9 show the results obtained with discrete threshold functions – Trivalent and Septivalent - with the activation of the Concepts 19 (cases in Table 8.5), 33 and 13, respectively. The objective is to allow a comparative analysis for the responses of those functions applying the five different numeric equivalents. The discrete function gets a better illustration in a table fashion then in a picture. In those tables the first five columns (on the left side) use the Septivalent threshold function with the five different numeric equivalents, and five others (on the right side) do the same for the Trivalent threshold function. Table 8.7 shows a comparison among the cases 4, 8, 10, 12, and 14 (Septivalent) and among the cases 3, 26, 27, 28, and 29 (Trivalent) with Concept 19 activated (+1) (see Table 8.5). This concept represents the highest positive energy of activation (see Table 8.4). It can be seen that there are no meaningful differences among the values in the Septivalent threshold function. The Trivalent threshold function shows some differences for concepts 18, 20, 24, 27 and 35.

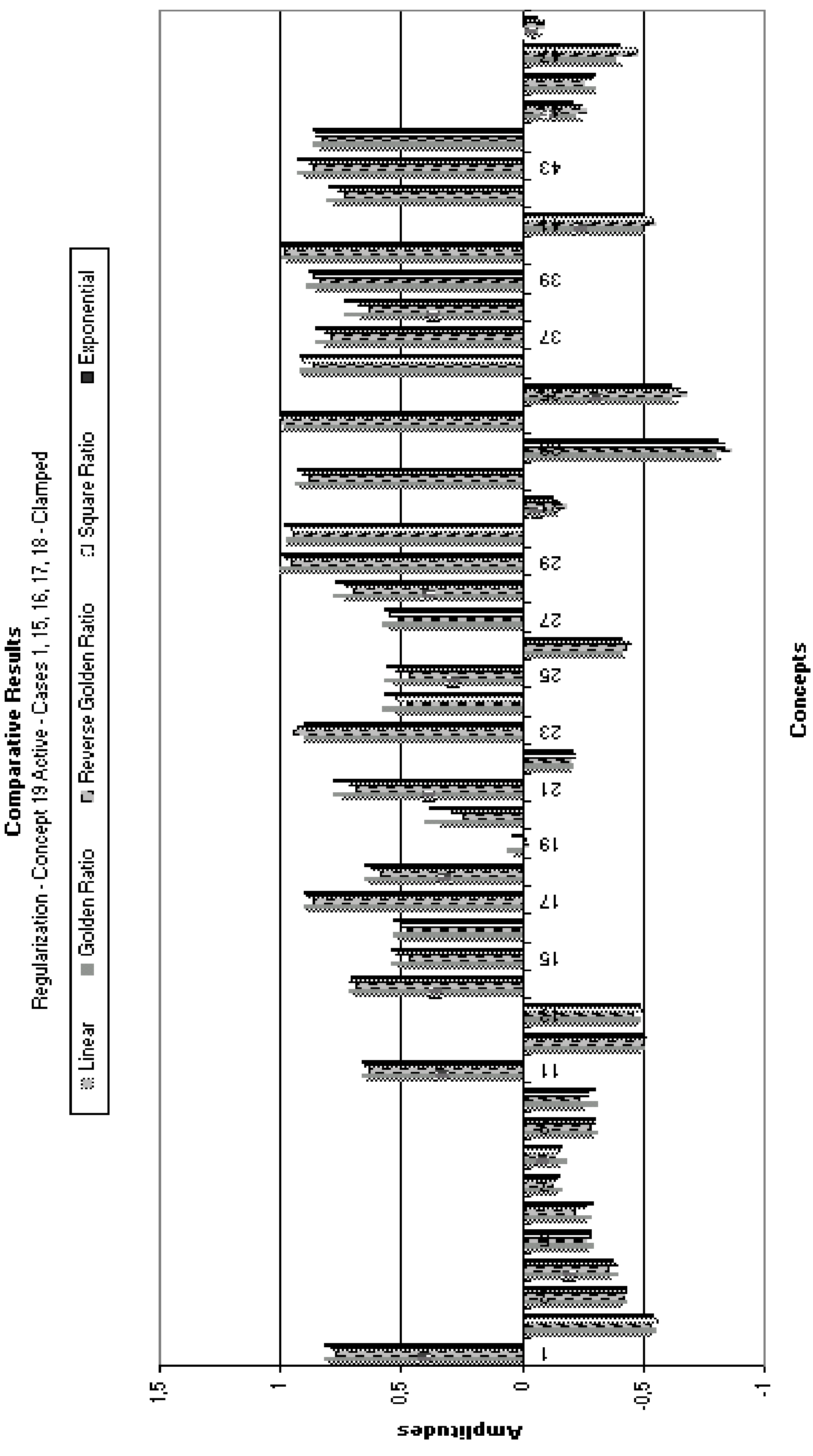

Figure 8.9 – Comparative results among different numeric equivalents (Regularization - Concept 19 = +1).

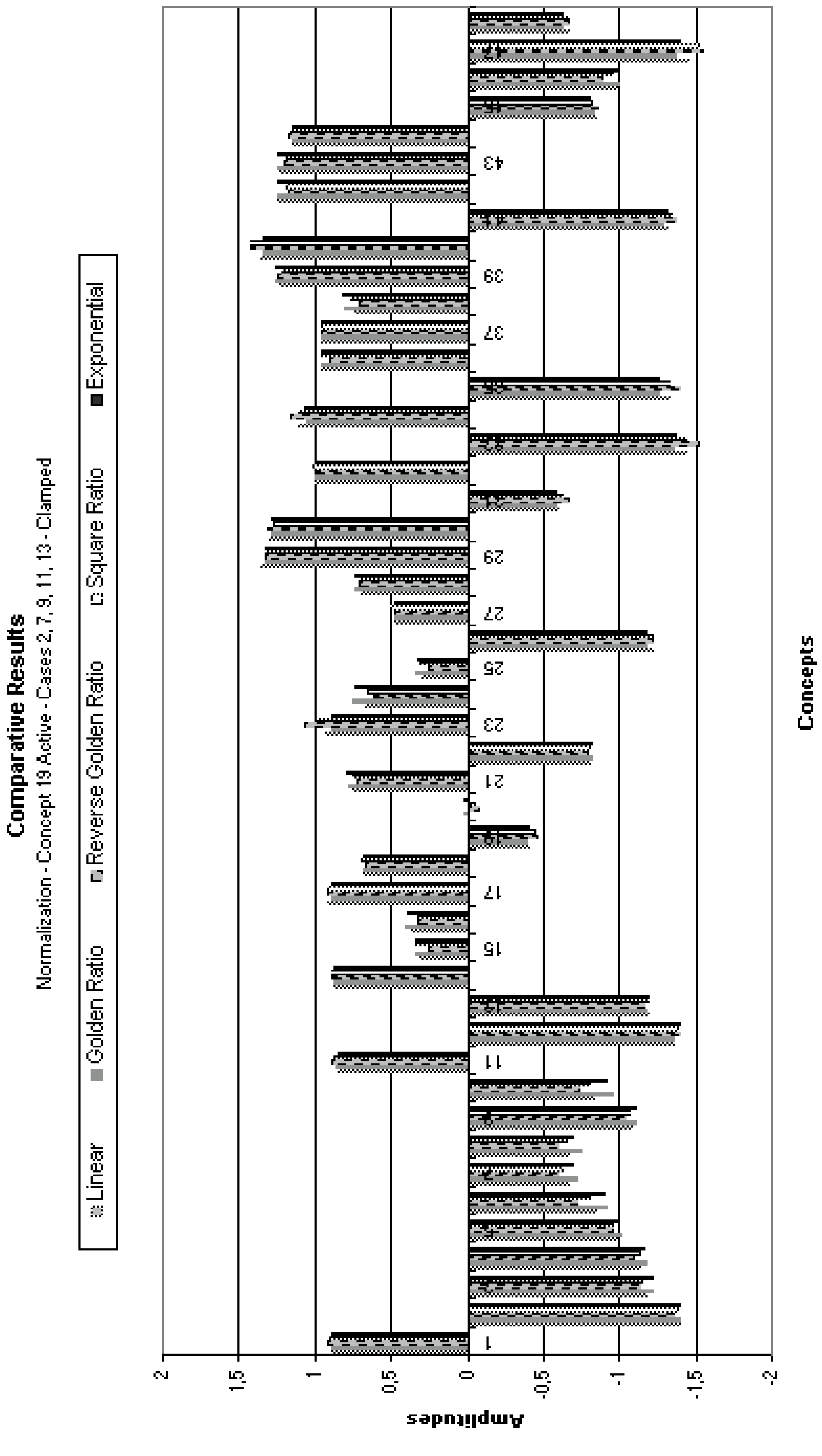

Figure 8.10– Comparative results among different numeric equivalents (Normalization - Concept 19 = +1).

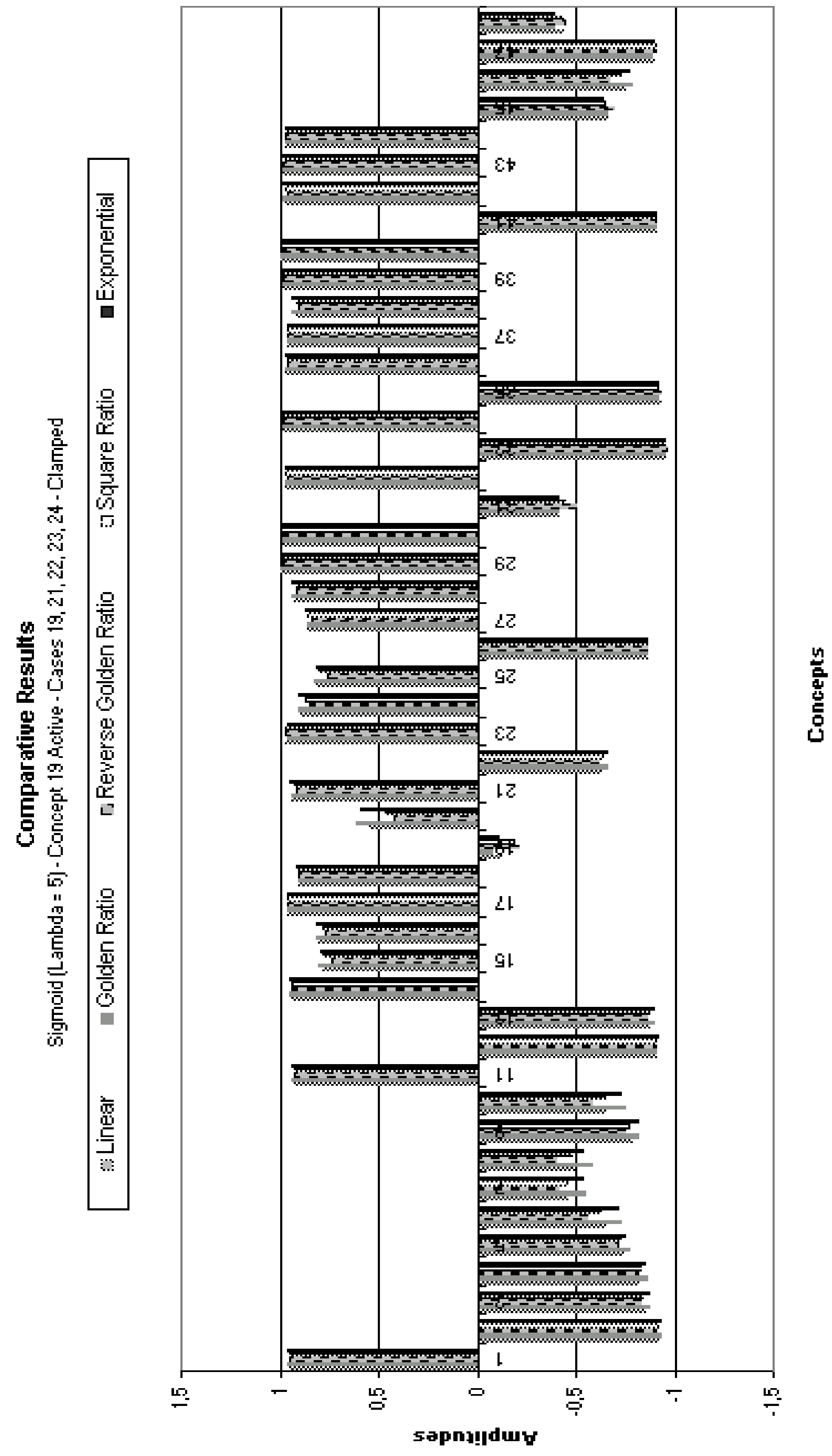

Figure 8.11 – Comparative results among different numeric equivalents (Sigmoid - Concept 19 = +1).

Table 8.8 shows a comparison among cases 42, 43, and from 50 to 57 (see Table 8.6). In these cases, Concept 33 is kept as active (+1). This concept presents the highest negative activation energy (see Table 8.4). As in Table 8.7, for the Septivalent threshold function, there are just some discrepancies between "neighboring" gradations (above or below), but they are not very meaningful differences. For the Trivalent threshold function, it can be verified some differences for concepts 15, 16, 24, and 41.

Similarly, Table 8.9 presents responses obtained with the Septivalent and Trivalent threshold functions for cases 44, 45, and from 58 to 65 (see Table 8.6) with concept 13 activated (+1). This concept was chosen because differently from the other previous ones, it has a lower positive energy of activation. Observing Table 8.9 it can be seen that the quality of the results is comparable to the previous ones. In the Trivalent threshold function mismatches appear in Concepts 15, 20, 24, and 41.

In general terms, the results with the Septivalent threshold function are very close. For some concepts some mismatch occurred, but only between "neighboring" gradations. These differences can be attributed to the following constraints: the numeric range of adjustment of each gradation, the different values of the numeric equivalent, and the mathematical rounding off of the numeric levels during the calculation. In spite of these mismatches, the results showed quite consistent values for the same concept. For the Trivalent threshold function, due to the fact it operates only with three levels; the mismatches are more meaningful than with the Septivalent cases. In the Trivalent case, in addition to the same previous constraints, the numeric values chosen as limit between ranges for the mathematical rounding off can cause greater discrepancies than in the

Septivalent case. However, in general, for these discrete values the uses of different numeric equivalents do not imply considerable differences in terms of levels of activation for each concept. This is true even when comparing the results with Trivalent and Septivalent threshold functions in those tables.

Table 8.6 - Tests with the Concept 33 (*Inertia to change/to start*) activated and tests with the Concept 13 (*Introversion*) activated.

Test Number	**Active Concept(s)**	**Numeric Equivalent**	**Threshold Function**	**Clamping**	**Convergence** (# iteration)
30	33)=>+1	Linear	Sigmoid (λ=5)	Yes	16
31	33)=>+1	Linear	Normalization	Yes	13
32	33)=>+1	Linear	Sigmoid (λ=5)	No	17
33	33)=>+1	Linear	Normalization	No	14
34	33)=>+1	Golden ratio	Sigmoid (λ=5)	Yes	16
35	33)=>+1	Golden ratio	Normalization	Yes	13
36	33)=>+1	Reverse golden ratio	Sigmoid (λ=5)	Yes	16
37	33)=>+1	Reverse golden ratio	Normalization	Yes	14
38	33)=>+1	Square ratio	Sigmoid (λ=5)	Yes	16
39	33)=>+1	Square ratio	Normalization	Yes	13
40	33)=>+1	Exponential	Sigmoid (λ=5)	Yes	17
41	33)=>+1	Exponential	Normalization	Yes	13
42	33)=>+1	Linear	Septivalent	Yes	6
43	33)=>+1	Linear	Trivalent	Yes	6
44	13)=>+1	Linear	Trivalent	Yes	6
45	13)=>+1	Linear	Septivalent	Yes	4
46	13)=>+1	Linear	Sigmoid (λ=5)	Yes	16
47	13)=>+1	Linear	Trivalent	No	6
48	13)=>+1	Linear	Septivalent	No	4
49	13)=>+1	Linear	Sigmoid (λ=5)	No	16
50	33) =>+1	Golden ratio	Septivalent	Yes	5
51	33) =>+1	Reverse golden ratio	Septivalent	Yes	5
52	33) =>+1	Square ratio	Septivalent	Yes	4
53	33) =>+1	Exponential	Septivalent	Yes	4
54	33) =>+1	Golden ratio	Trivalent	Yes	7
55	33) =>+1	Reverse golden ratio	Trivalent	Yes	6
56	33) =>+1	Square ratio	Trivalent	Yes	7
57	33) =>+1	Exponential	Trivalent	Yes	7
58	13)=>+1	Golden ratio	Septivalent	Yes	4
59	13)=>+1	Reverse golden ratio	Septivalent	Yes	5
60	13)=>+1	Square ratio	Septivalent	Yes	4
61	13)=>+1	Exponential	Septivalent	Yes	5
62	13)=>+1	Golden ratio	Trivalent	Yes	9
63	13)=>+1	Reverse golden ratio	Trivalent	Yes	11
64	13)=>+1	Square ratio	Trivalent	Yes	7
65	13)=>+1	Exponential	Trivalent	Yes	6

Table 8.7 - Comparative table of discrete threshold functions – Trivalent and Septivalent - using different numeric equivalents: *linear* (4, 3), *golden ratio* (8, 26), *reverse golden ratio* (10, 27), *square ratio* (12, 28), *exponential* (14, 29). Concept 19 active (+1) (see Table 8.5).

	Case →	*4*	*8*	*10*	*12*	*14*	*3*	*26*	*27*	*28*	*29*
	Concepts ↓/ Active concept →	*19*	*19*	*19*	*19*	*19*	*19*	*19*	*19*	*19*	*19*
In the individual	01. Joy	A	A	AM	AM	A	+1	+1	+1	+1	+1
	02. Sadness	D	DP	D	D	DP	0	0	0	0	0
	03. Fear	DP	DP	D	D	DP	0	0	0	0	0
	04. Anger	DP	NC	D	D	DP	0	0	0	0	0
	05. Repulsion	DP	NC	DP	DP	DP	0	0	0	0	0
	06. Guilt	DP	NC	DP	DP	DP	0	0	0	0	0
	07. Envy	NC	NC	DP	DP	NC	0	0	0	0	0
	08. Jealousy	NC	NC	DP	DP	NC	0	0	0	0	0
	09. Grief	DP	NC	DP	DP	DP	0	0	0	0	0
	10. Shame	DP	NC	DP	DP	DP	0	0	0	0	0
	11. Feeling of empathy	A	AP	A	A	AP	+1	+1	+1	+1	+1
	12. Frustration	DP	DP	D	D	DP	0	0	0	0	0
	13. Introversion	DP	DP	D	D	DP	0	0	0	0	0
	14. Extroversion	A	AP	A	A	A	+1	+1	+1	+1	+1
	15. Desire for independence	A	AP	A	A	AP	+1	+1	+1	+1	+1
	16. Overestimation of time	A	AP	A	A	AP	+1	+1	+1	+1	+1
	17. Desire for Achievement	AM	A	AM	AM	A	+1	+1	+1	+1	+1
	18. Desire for affiliation/association	A	AP	A	A	AP	+1	+1	0	+1	+1
	19. Desire for power/domination	NC	NC	NC	NC	NC	0	0	0	0	0
	20. Desire to attract attention	AP	AP	AP	AP	AP	0	+1	0	0	0
	21. Interest	A	A	A	A	A	+1	+1	+1	+1	+1
	22. Desire for vengeance	DP	NC	DP	DP	NC	0	0	0	0	0
	23. Motivation	AM	A	AM	AM	A	+1	+1	+1	+1	+1
	24. Leisure	A	AP	A	A	AP	0	+1	0	0	+1
	25. To be rewarded	A	AP	A	A	AP	+1	+1	+1	+1	+1
	26. To be threatened	DP	DP	D	D	DP	0	0	0	0	0
	27. To be accepted	A	AP	A	A	AP	+1	+1	0	+1	+1
	28. To be important / worthy	A	A	A	A	A	+1	+1	+1	+1	+1
	29. Self-esteem	AM	AM	AM	AM	AM	+1	+1	+1	+1	+1
	30. Self-confidence	AM	A	AM	AM	AM	+1	+1	+1	+1	+1
	31. Arrogance	NC	NC	DP	DP	NC	0	0	0	0	0
	32. To go on / to persevere	AM	AM	AM	AM	AM	+1	+1	+1	+1	+1
	33. Inertia to change / to start	D	D	DM	DM	D	-1	-1	-1	-1	-1
	34. To act	AM	AM	AM	AM	AM	+1	+1	+1	+1	+1
	35. To flee	D	DP	D	D	DP	-1	-1	-1	-1	0
	36. To believe in the possibility of	AM	A	AM	AM	A	+1	+1	+1	+1	+1
In the group	37. Planning and goals	A	A	AM	AM	A	+1	+1	+1	+1	+1
	38. Organization	A	AP	A	A	A	+1	+1	+1	+1	+1
	39. Cooperation	AM	A	AM	AM	A	+1	+1	+1	+1	+1
	40. Satisfaction	AM	AM	AM	AM	AM	+1	+1	+1	+1	+1
	41. Individualism	DP	DP	D	D	DP	0	0	0	0	0
	42. Confidence in the group	A	AP	A	AM	A	+1	+1	+1	+1	+1
	43. Dedication	AM	A	AM	AM	A	+1	+1	+1	+1	+1
	44. Success	AM	A	AM	AM	A	+1	+1	+1	+1	+1
	45. Authoritarian leadership	DP	NC	DP	DP	NC	0	0	0	0	0
	46. Punishment	DP	NC	DP	DP	DP	0	0	0	0	0
	47. Stress	DP	NC	D	D	DP	0	0	0	0	0
	48. Competition	NC	NC	NC	NC	NC	0	0	0	0	0

Table 8.8 - Comparative table of discrete threshold functions – Trivalent and Septivalent - using different numeric equivalents: *linear* (42, 43), *golden ratio* (50, 54), *reverse golden ratio* (51, 55), *square ratio* (52, 56), *exponential* (53, 57). Concept 33 active (+1) (see Table 8.6).

	Case →	*42*	*50*	*51*	*52*	*53*	*43*	*54*	*55*	*56*	*57*
	Concepts ↓/ Active concept →	*33. +1*	*33. +1*	*33. +1*	*33. +1*	*33. +1*	*33. +1*	*33. +1*	*33. +1*	*33. +1*	*33. +1*
In the individual	01. Joy	D	D	DM	DM	D	-1	-1	-1	-1	-1
	02. Sadness	A	AP	A	A	AP	0	0	0	0	0
	03. Fear	AP	AP	A	A	AP	0	0	0	0	0
	04. Anger	AP	AP	A	A	AP	0	0	0	0	0
	05. Repulsion	AP	AP	A	AP	AP	0	0	0	0	0
	06. Guilt	AP	AP	AP	AP	AP	0	0	0	0	0
	07. Envy	AP	NC	AP	AP	NC	0	0	0	0	0
	08. Jealousy	AP	NC	AP	AP	NC	0	0	0	0	0
	09. Grief	AP	AP	A	AP	AP	0	0	0	0	0
	10. Shame	AP	AP	AP	AP	AP	0	0	0	0	0
	11. Feeling of empathy	D	DP	D	D	DP	-1	-1	-1	-1	-1
	12. Frustration	A	AP	A	A	AP	0	0	0	0	0
	13. Introversion	AP	AP	A	A	AP	0	0	0	0	0
	14. Extroversion	D	DP	D	D	D	-1	-1	-1	-1	-1
	15. Desire for independence	DP	DP	D	D	DP	-1	-1	0	-1	-1
	16. Overestimation of time	DP	DP	D	D	DP	-1	-1	0	-1	-1
	17. Desire for Achievement	D	D	DM	DM	D	-1	-1	-1	-1	-1
	18. Desire for affiliation/association	D	DP	D	D	DP	-1	-1	-1	-1	-1
	19. Desire for power/domination	NC	NC	AP	NC	NC	0	0	0	0	0
	20. Desire to attract attention	DP	DP	DP	DP	DP	0	0	0	0	0
	21. Interest	D	D	D	D	D	-1	-1	-1	-1	-1
	22. Desire for vengeance	AP	NC	AP	AP	NC	0	0	0	0	0
	23. Motivation	D	D	DM	DM	D	-1	-1	-1	-1	-1
	24. Leisure	D	DP	D	D	DP	-1	-1	0	-1	-1
	25. To be rewarded	DP	DP	D	D	DP	-1	-1	-1	-1	-1
	26. To be threatened	A	AP	A	A	AP	0	0	0	0	0
	27. To be accepted	D	DP	D	D	DP	-1	-1	-1	-1	-1
	28. To be important / worthy	D	D	D	D	D	-1	-1	-1	-1	-1
	29. Self-esteem	DM	DM	DM	DM	DM	-1	-1	-1	-1	-1
	30. Self-confidence	DM	DM	DM	DM	DM	-1	-1	-1	-1	-1
	31. Arrogance	AP	NC	AP	AP	NC	0	0	0	0	0
	32. To go on / to persevere	DM	D	DM	DM	DM	-1	-1	-1	-1	-1
	33. Inertia to change / to start	A	A	AM	AM	A	+1	+1	+1	+1	+1
	34. To act	DM	DM	DM	DM	DM	-1	-1	-1	-1	-1
	35. To flee	A	AP	A	A	AP	+1	+1	+1	+1	+1
	36. To believe in the possibility of	DM	D	DM	DM	D	-1	-1	-1	-1	-1
In the group	37. Planning and goals	D	D	DM	DM	D	-1	-1	-1	-1	-1
	38. Organization	D	DP	D	D	D	-1	-1	-1	-1	-1
	39. Cooperation	DM	D	DM	DM	D	-1	-1	-1	-1	-1
	40. Satisfaction	DM	DM	DM	DM	DM	-1	-1	-1	-1	-1
	41. Individualism	A	AP	A	A	AP	0	0	+1	+1	0
	42. Confidence in the group	DM	D	DM	DM	D	-1	-1	-1	-1	-1
	43. Dedication	DM	DM	DM	DM	DM	-1	-1	-1	-1	-1
	44. Success	DM	D	DM	DM	D	-1	-1	-1	-1	-1
	45. Authoritarian leadership	AP	NC	A	AP	NC	0	0	0	0	0
	46. Punishment	AP	AP	A	AP	AP	0	0	0	0	0
	47. Stress	A	AP	A	A	AP	0	0	0	0	0
	48. Competition	AP	NC	AP	AP	NC	0	0	0	0	0

Table 8.9 - Comparative table of discrete threshold functions – Trivalent and Septivalent - using different numeric equivalents: *linear* (45, 44), *golden ratio* (58, 62), *reverse golden ratio* (59, 63), *square ratio* (60, 64), *exponential* (51, 65). Concept 13 active (+1) (see Table 8.6).

	Case →	45	58	59	60	61	44	62	63	64	65
	Concepts ↓/ Active concept →	13. +1	13 +1	13 +1	13 +1	13 +1	13. +1	13. +1	13. +1	13. +1	13. +1
In the individual	01. Joy	D	D	DM	DM	D	-1	-1	-1	-1	-1
	02. Sadness	A	AP	A	A	AP	0	0	0	0	0
	03. Fear	AP	AP	A	A	AP	0	0	0	0	0
	04. Anger	AP	AP	A	A	AP	0	0	0	0	0
	05. Repulsion	AP	AP	A	AP	AP	0	0	0	0	0
	06. Guilt	AP	AP	AP	AP	AP	0	0	0	0	0
	07. Envy	AP	NC	AP	AP	NC	0	0	0	0	0
	08. Jealousy	AP	NC	AP	AP	NC	0	0	0	0	0
	09. Grief	AP	AP	A	AP	AP	0	0	0	0	0
	10. Shame	AP	AP	AP	AP	AP	0	0	0	0	0
	11. Feeling of empathy	D	DP	D	D	D	-1	-1	-1	-1	-1
	12. Frustration	A	AP	A	A	AP	0	0	0	0	0
	13. Introversion	A	AP	A	A	AP	0	0	0	0	0
	14. Extroversion	D	D	DM	D	D	-1	-1	-1	-1	-1
	15. Desire for independence	DP	DP	D	D	DP	-1	-1	0	-1	-1
	16. Overestimation of time	DP	DP	D	D	DP	-1	-1	-1	-1	-1
	17. Desire for Achievement	D	D	DM	DM	D	-1	-1	-1	-1	-1
	18. Desire for affiliation/association	D	DP	D	D	DP	-1	-1	-1	-1	-1
	19. Desire for power/domination	NC	NC	NC	NC	NC	0	0	0	0	0
	20. Desire to attract attention	DP	DP	DP	DP	DP	0	-1	0	0	0
	21. Interest	D	D	D	D	D	-1	-1	-1	-1	-1
	22. Desire for vengeance	AP	NC	AP	AP	AP	0	0	0	0	0
	23. Motivation	DM	D	DM	DM	D	-1	-1	-1	-1	-1
	24. Leisure	D	DP	D	D	DP	-1	-1	0	-1	-1
	25. To be rewarded	DP	DP	D	D	DP	-1	-1	-1	-1	-1
	26. To be threatened	A	AP	A	A	AP	0	0	0	0	0
	27. To be accepted	D	DP	D	D	DP	-1	-1	-1	-1	-1
	28. To be important / worthy	D	D	D	D	D	-1	-1	-1	-1	-1
	29. Self-esteem	DM	DM	DM	DM	DM	-1	-1	-1	-1	-1
	30. Self-confidence	DM	DM	DM	DM	DM	-1	-1	-1	-1	-1
	31. Arrogance	AP	NC	AP	AP	NC	0	0	0	0	0
	32. To go on / to persevere	DM	D	DM	DM	D	-1	-1	-1	-1	-1
	33. Inertia to change / to start	A	A	AM	AM	A	+1	+1	+1	+1	+1
	34. To act	DM	DM	DM	DM	DM	-1	-1	-1	-1	-1
	35. To flee	A	AP	A	DM	AP	+1	+1	+1	+1	+1
	36. To believe in the possibility of	D	D	DM	A	D	-1	-1	-1	-1	-1
In the group	37. Planning and goals	D	DM	DM	DM	D	-1	-1	-1	-1	-1
	38. Organization	D	A	D	D	D	-1	-1	-1	-1	-1
	39. Cooperation	DM	A	DM	DM	DM	-1	-1	-1	-1	-1
	40. Satisfaction	DM	A	DM	DM	DM	-1	-1	-1	-1	-1
	41. Individualism	A	A	A	A	AP	+1	0	+1	+1	0
	42. Confidence in the group	DM	AP	DM	DM	D	-1	-1	-1	-1	-1
	43. Dedication	DM	AP	DM	DM	DM	-1	-1	-1	-1	-1
	44. Success	DM	AP	DM	DM	D	-1	-1	-1	-1	-1
	45. Authoritarian leadership	AP	A	A	AP	AP	0	0	0	0	0
	46. Punishment	AP	AP	AP	AP	AP	0	0	0	0	0
	47. Stress	A	D	A	A	AP	0	0	0	0	0
	48. Competition	AP	A	AP	AP	NC	0	0	0	0	0

Figures 8.12 (cases 31, 35, 37, 39, and 41 – see Table 8.6) and 8.13 (cases 30, 34, 36, 38, and 40 – see Table 8.6) place together the outputs obtained with Normalization and Sigmoid (λ=5) threshold functions using the five numeric equivalents. As in previous cases, there are no meaningful differences among the outputs for the different numeric equivalents. Figure 8.14 (cases 30 and 31 – see Table 8.6) compares the outputs between Sigmoid and Normalization threshold functions using the Linear numeric equivalent. Also in this case, except in concept 20, the "profiles" of the results match. Figures 8.15 (cases 30 and 32 – see Table 8.6) and 8.16 (cases 31 and 33 – see Table 8.6) show a comparison between clamped and no-clamped outputs with Sigmoid and Normalization threshold functions. It can be seen that there are no meaningful differences between the responses for the same concepts. For such cases clamped and no-clamped conditions generate very similar results.

Cases 40, 41 and 42 are placed together in Figure 8.17 (clamped), and cases 43, 44, and 45 are placed together in Figure 8.18 (no-clamped). It can be seen that there is coherence in relation to the signal of the responses. However, there are significant differences between the Trivalent and Sigmoid threshold functions, as it occurred in Figure 8.3. In Figure 8.17 as well as in 8.18 some concepts presenting high levels of activation with the Sigmoid threshold function (for example, concepts 2,3,4,5,6, 9,10,22,26,45,46,47) are nulls with the Trivalent threshold function. But, comparing the Sigmoid and the Septivalent threshold function there is more proximity between the values. Also for these cases, clamped and no-clamped effect has provided very similar responses.

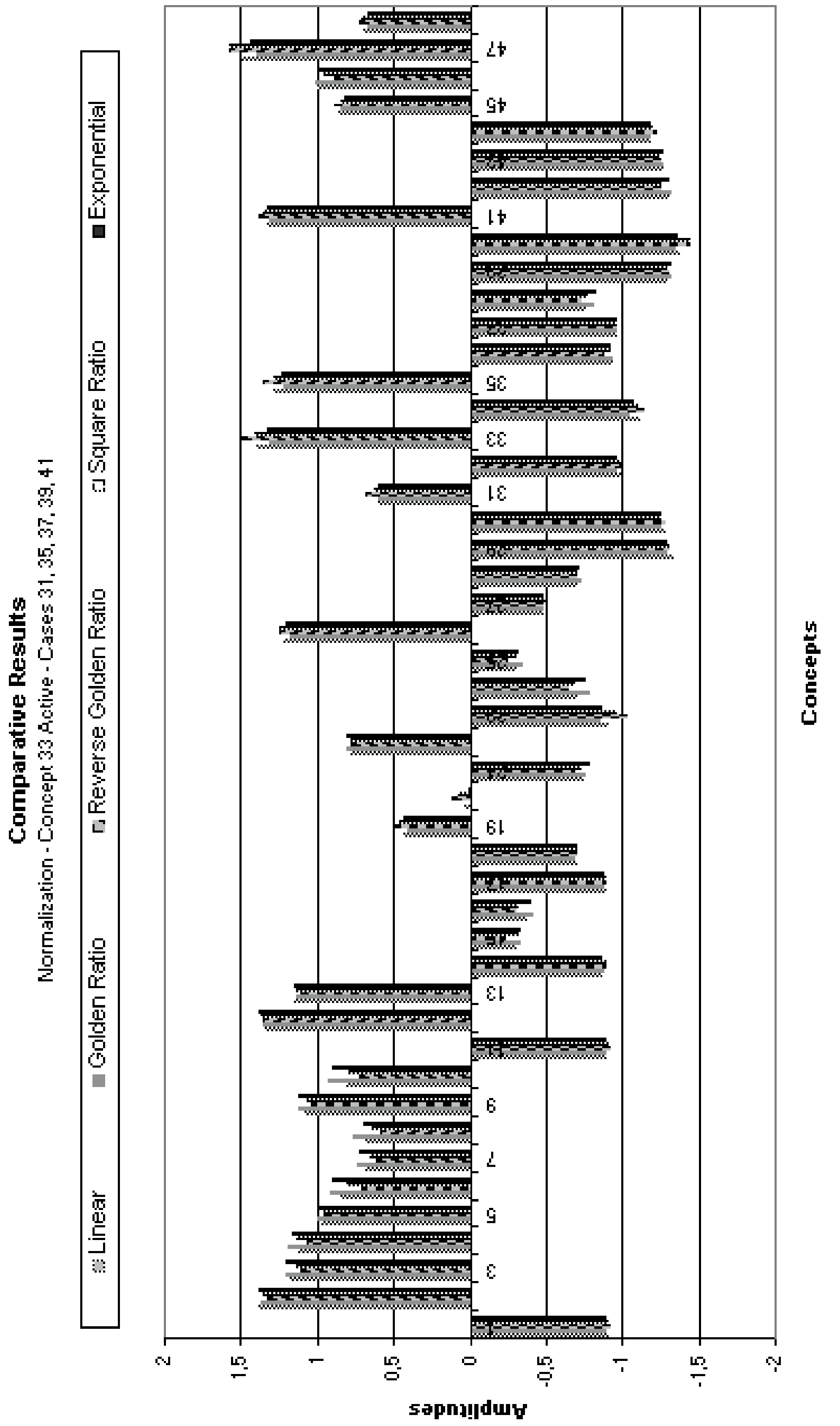

Figure 8.12 - Comparative results among different numeric equivalents (Normalization - Concept 33 = +1).

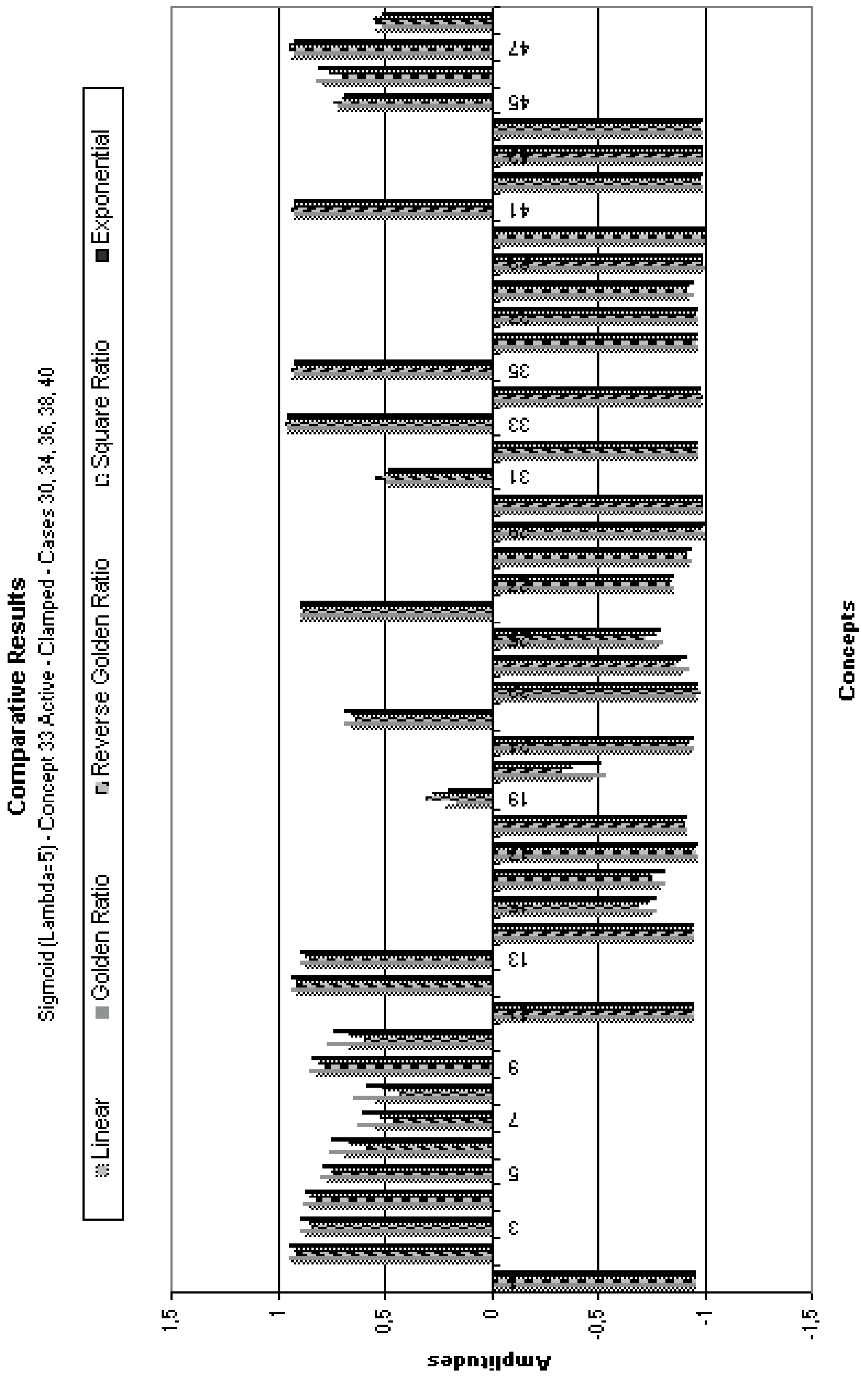

Figure 8.13– Comparative results among different numeric equivalents (Sigmoid - Concept 33 = +1).

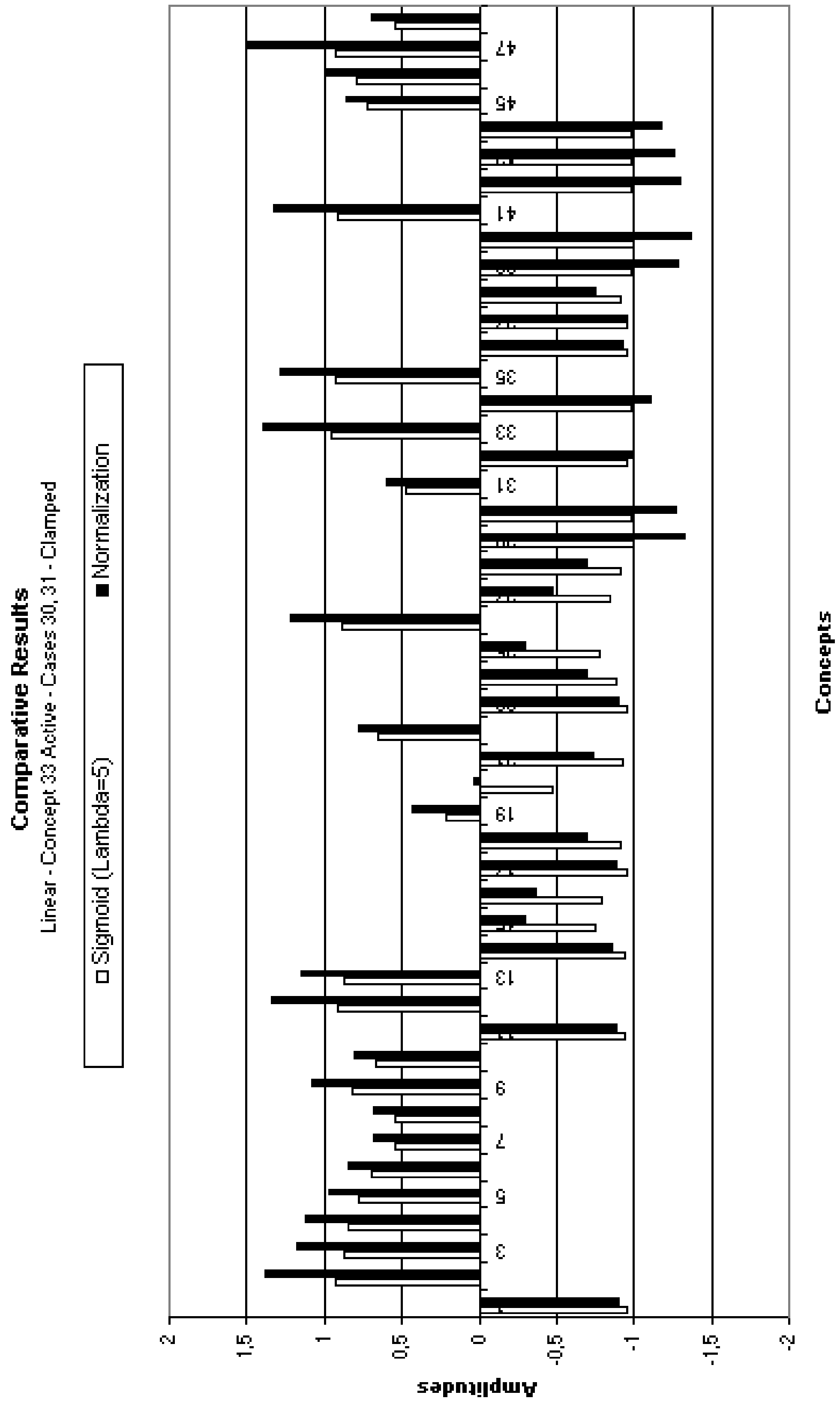

Figure 8.14 –Comparative results between Normalization and Sigmoid (Concept 33 = +1).

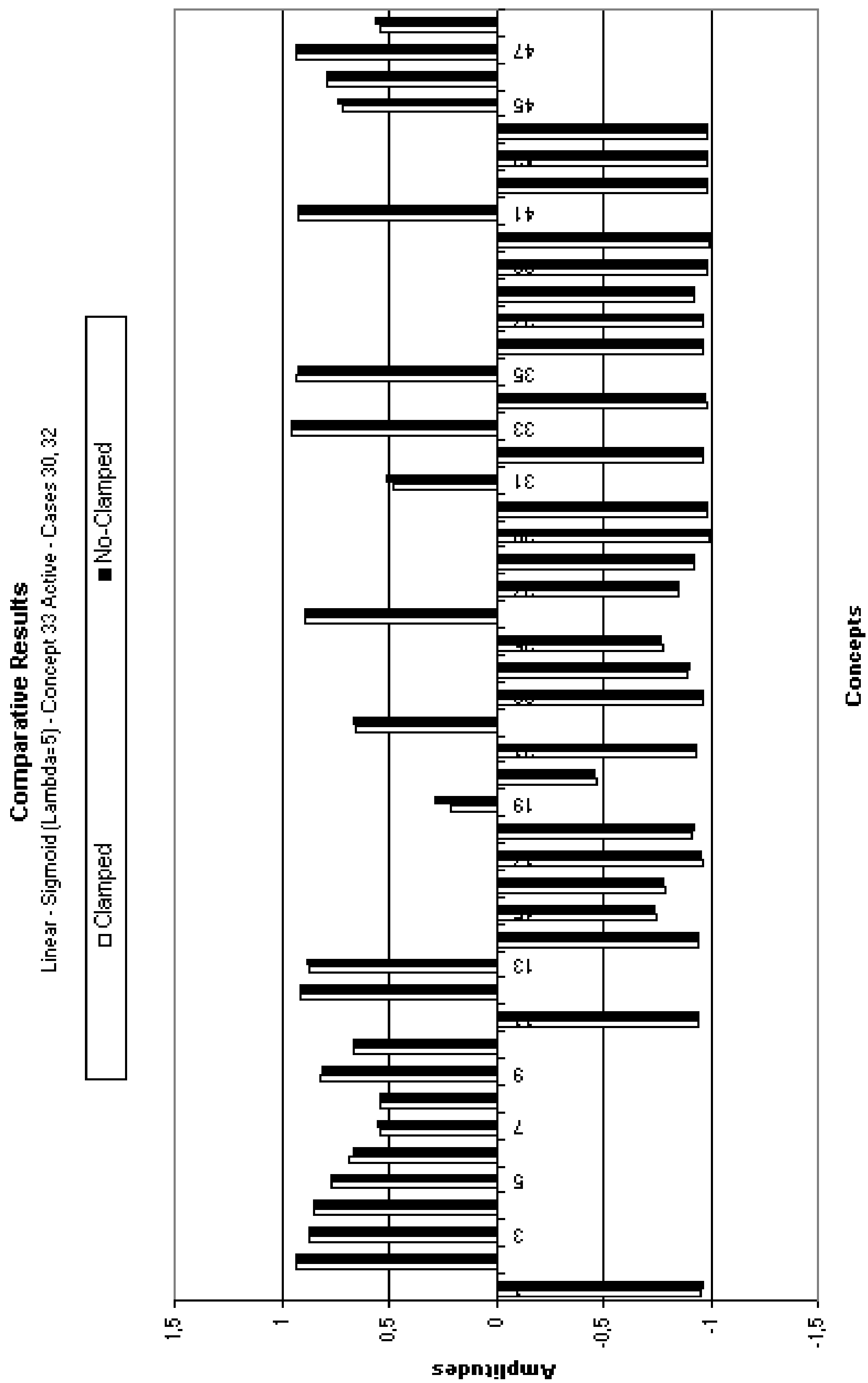

Figure 8.15 - Comparative results between Sigmoid clamped and no-clamped (Concept 33 = +1).

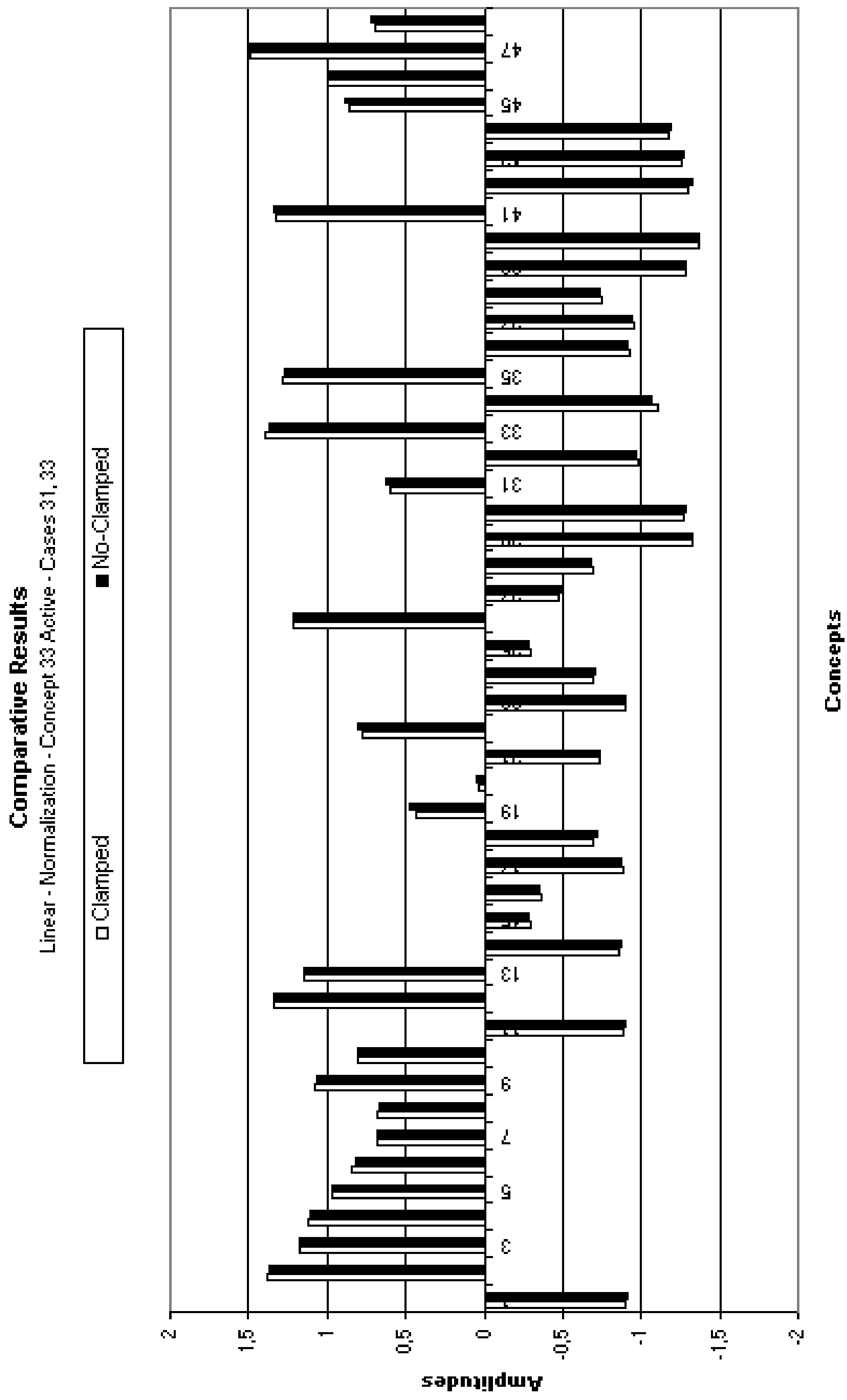

Figure 8.16 – Comparative results between Normalization clamped and no-clamped (Concept 33 = +1).

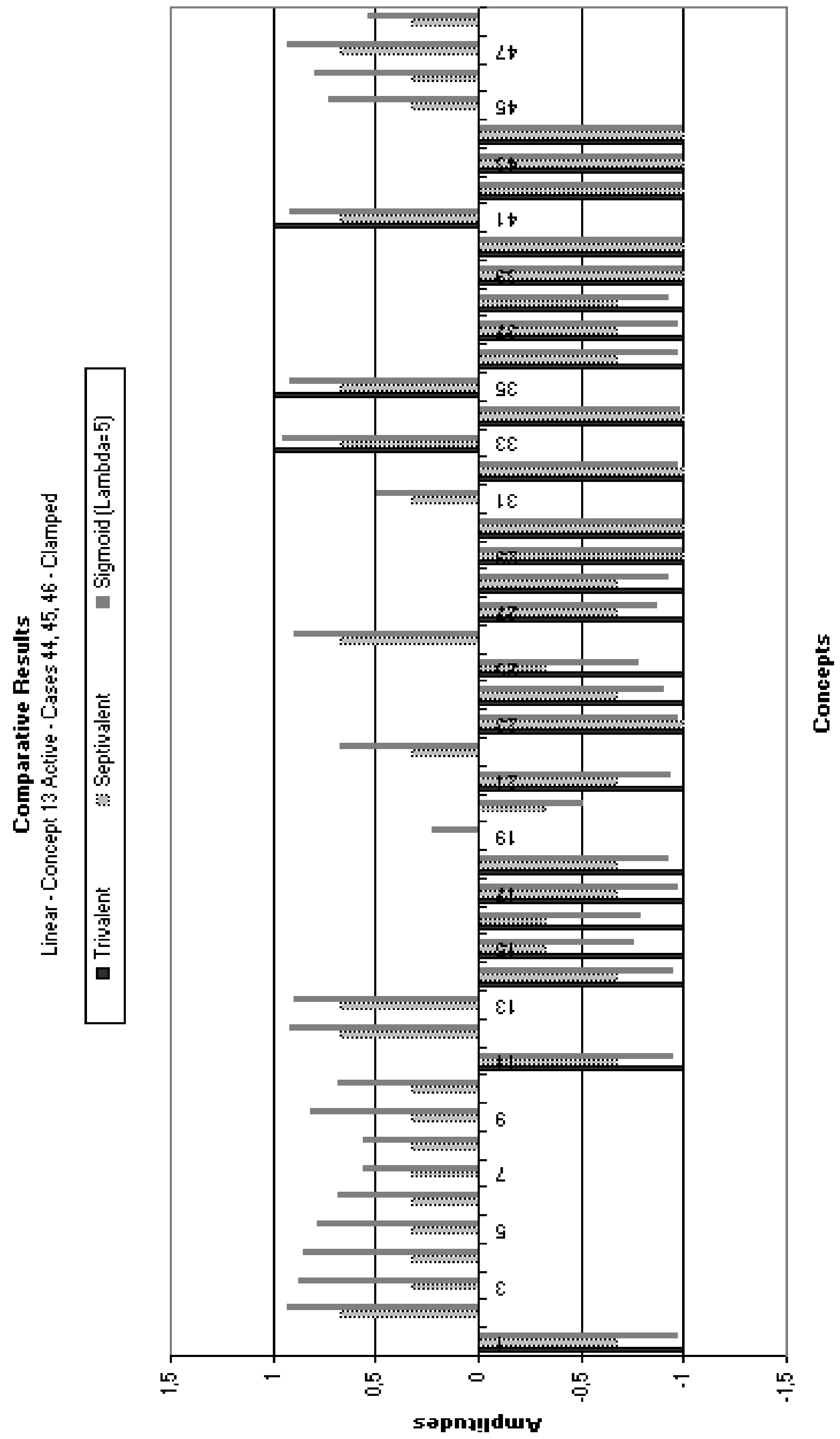

Figure 8.17 – Comparative results among Sigmoid, Trivalent, and Septivalent (clamped - Concept 13 = +1).

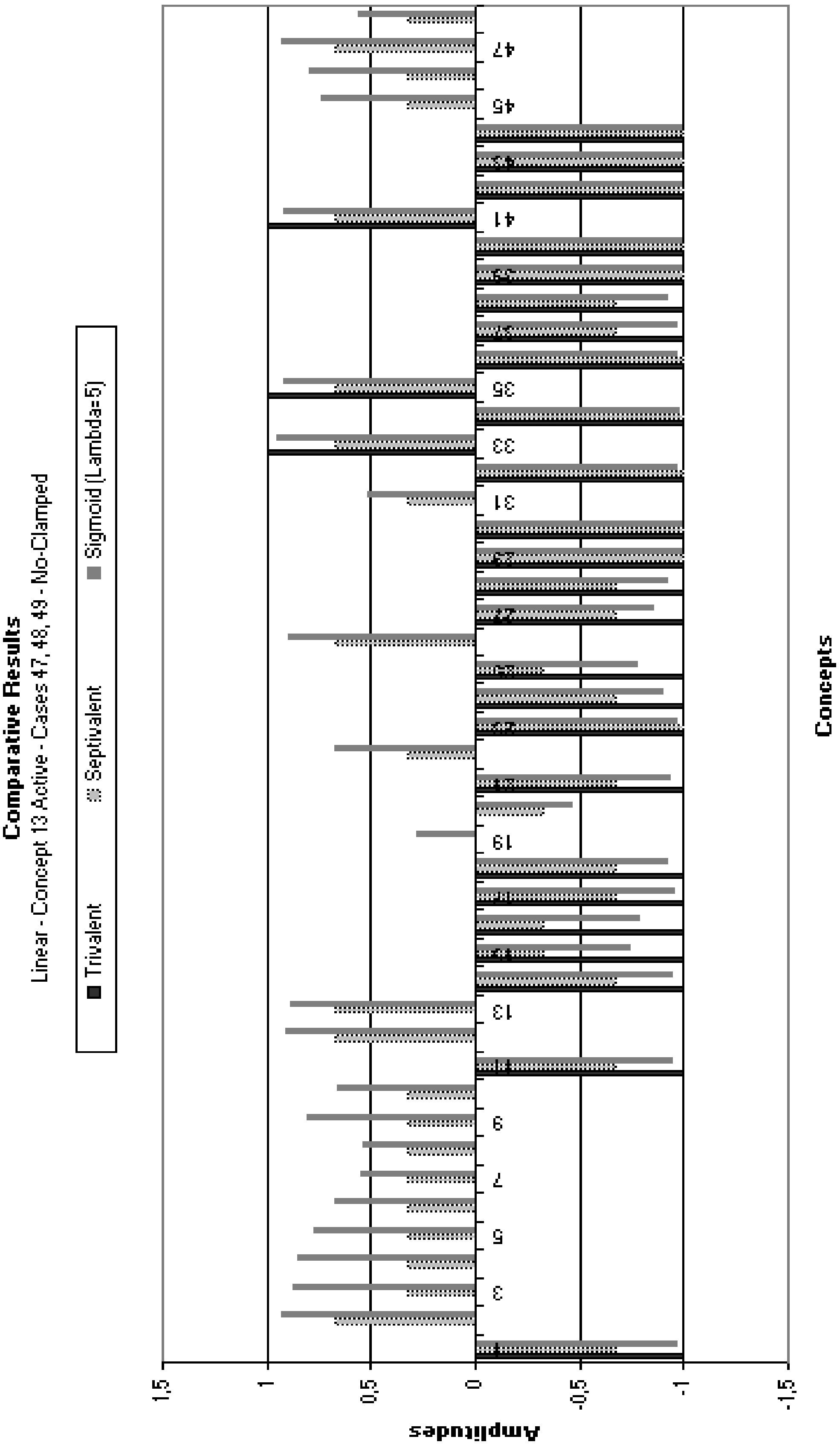

Figure 8.18 - Comparative results among Sigmoid, Trivalent, and Septivalent (no-clamped - Concept 13 = +1).

8.3.2 Conclusions About Numeric Tendencies

Based on the numeric tests it is possible to assume the following considerations:

a) Different numeric equivalents do not imply meaningful differences in the responses, for any of the threshold functions tested here;

b) In spite of some differences in the amplitudes of the responses, the performances of continual threshold functions (Normalization, Regularization and Sigmoid) generate similar profiles of the outcomes;

c) The Sigmoid threshold function shows a kind of "saturation", which can simulate a common feature in psychological perceptual models;

d) In relation to the average value, Normalization tends to amplify the values with the opposite signal and to attenuate the values with the same signal (or even to change the signal);

e) The discrete threshold functions (Trivalent and Septivalent) give a qualitative idea about the performance of the system. The Trivalent works as a strict "filter" of information and it specially points out the more active concepts. In addition to a qualitative idea about the response, the Septivalent threshold function provides values closer to the continual threshold functions and in the same scale proposed in the software data entry;

f) In spite of some discrepancies, the Trivalent and the Septivalent threshold functions show close results and together they give a very good qualitative idea about the system behavior;

g) Practical differences between clamped and no-clamped operations were not found. Probably the size of FCM connection matrix is the responsible for that. However, more tests would have to be tried out to conclude if this fact always happens.

h) The convergence of the responses occurred in a range between 4 and 23 iterations through the equality of the last two inputs. Therefore, it can be said that this aspect was not critical and the software criteria of convergence attends the needs of processing of the data.

Therefore, based on the assumptions above some choices have to be made. The discrete threshold functions present a pattern of responses equivalent to continual ones, and especially they better express a qualitative idea approximating a fuzzy variable. Then, in the sequence of this research only the responses obtained with Septivalent and Trivalent threshold functions will be adopted to analyze the interaction among the concepts.

8.4 Conclusions

This chapter has accounted for the statistics about the data collection and numeric tendencies of the implementation. Statistical parameters have been calculated and some of their aspects have been stressed. Based on such parameters a profile of the experts' responses has been illustrated. The main aspects to be evidenced have been the amount of *NC* gradation answered and the small amount of *DP* gradation answered. Three experts answered *NC* for more than 50% of the total of responses. For all the experts the *DP* gradation represents the smallest amount of all the answers. This fact is probably related to perceptual aspects. The statistical analysis has allowed to have a good notion about the quality of the data collection. Also, it has pointed out some experts' beliefs and their way to deal with the questionnaire.

The analysis of numeric tendencies has shown certain independence between the choice of the numeric parameters and the behavior of the system. The performed tests have shown that, for the same initial condition, changes in numerical parameters or different combination of those have not influenced the general profile of the outcomes. The main mismatches have occurred in terms of the amplitude of the values especially in relation to Trivalent threshold function. In spite of that, the discrete threshold functions (Septivalent and Trivalent) have demonstrated a good performance to express the behavior of the system allowing a quick qualitative analysis of the outcomes. Also, the choice of the numeric equivalent and clamped or no-clamped activation have not demonstrated meaningful weight in the quality of the responses Therefore, in the next chapter the analysis will only take into account the discrete threshold functions, the Linear numeric equivalent, and clamped activation to analyze the interaction among the concepts and their psychological interpretation.

Chapter 9

ANALYSIS OF INTERACTION AMONG CONCEPTS

9.1 Introduction

In this chapter an analysis of interaction among the concepts is performed. This is the main goal of the FCM technique and also the most important purpose in this research. In fact, all the numeric approximation and choices made in the last chapters aimed at modeling the interaction among the psychological concepts, in the most precise fashion as possible.

Also in this chapter several cases are suggested to evaluate the behavior of the FCM system. Such cases try to simulate how a concept or a set of concepts influences the entire system. In some cases only one concept is taken and in others a set of concepts, which in latter tries to represent a real situation. Then the computational calculation is carried out and the outcomes are analyzed. The most meaningful results are stressed with the aim of interpreting the possible psychological reality that was evoked.

The obtained results have shown quite coherence with expected outcomes based on common sense experiences. Some results could be questioned but there is not a precise or single conclusion. Indeed, the proposed FCM system expresses a synthesis of the experts' beliefs on the relationship among the concepts. The system simulations bring out the experts' thoughts, i.e., how they judge that the concepts are interweaved. Some of their beliefs they consciously know but others are a kind of "hidden pattern" related to unconscious beliefs. The results give clues to understand what is going on in a situation according to the experts' standpoint.

The quality of the results allows concluding that the FCM tool is able to model psychological processes making possible inferences and prediction about issues directly or indirectly associated with the concepts that were chosen. Thus, in addition to statistical analysis and *psychological tests*, which are ordinary tools in research in Psychology, the FCM technique could also be applied. Therefore, as it happens with other tools, the FCM technique would help to provide further objectiveness in dealing with subjects in Psychology. It can offer experts a lot of clues to aid in understanding the psychological reality (individual, social, and decision-making process) and also their own beliefs.

Next, the cases that were tried out are described. An analysis of each one is made and the main aspects are emphasized. The final section of this chapter presents a general analysis of the results and some suggestions for uses and improvements of this tool.

9.2 Analysis of Interaction Among Concepts

The analysis of interaction among concepts is one of the most important parts of this whole study. Fortunately, the results obtained here are able to validate this method as a mathematical tool for psychological studies. In last chapter it was shown that the numerical behavior of the system is somehow independent of the numeric attributions. Even using various combination of numeric factors the results for the same input show congruity. So, for the analysis of the conceptual interaction the following numeric parameters of simulation will be chosen: Linear numeric equivalent, Septivalent and Trivalent threshold functions, and clamped activation. These options were chosen because there are no expressive differences among the results in spite of the different numeric parameters. Moreover, Septivalent and Trivalent threshold functions can together give a better idea about the interactions among concepts. Trivalent tends to emphasize the more relevant effects and Septivalent gives a good idea of the proportion among concepts, so the interaction among the concepts has a better feature. Also, these threshold functions show coherent results with other continual functions and provide a final literal approximation that facilitates the conceptual analysis.

Several tests are proposed to analyze the behavior of the FCM system in terms of interaction among concepts. Such tests, here called 'cases', try to check how a concept or a set of concepts can influence the whole system. In some cases only one concept is taken and in others a set of concepts, which in latter tries to represent a real situation. Based on common sense thoughts, it is here assumed that a desirable influence in the system consists of the positive activation of the concepts: *Joy, Feeling of empathy, To go on / to persevere, To act, Self-esteem, Self-confidence, Desire for achievement, Interest, Motivation, Planning and goals, Organization, Cooperation, Satisfaction, Confidence in group, Dedication* and *Success*. On the other hand, undesirable influences here means to activate positively the concepts: *Sadness, Envy, Jealousy, Grief, Shame, Frustration, Desire for vengeance, To be threatened, Arrogance, Inertia to change / start, To flee, Individualism*, and *Stress*.

Firstly, the results of the previous cases analyzed in last chapter will be considered. Tables 8.5 and 8.7 show the effects of activation of the concept *Desire for domination / power* (19) taking the cases 3 and 4. This concept positively activates 25 concepts and negatively just 2 (case 3). According to those data *Desire for domination / power* <u>increases</u> mainly the concepts *Desire for achievement*, *Motivation*, *Self-esteem*, *Self-confidence*, *To* *go on / persevere*, *To act*, *To believe in the possibility of*, *Cooperation*, *Satisfaction*, *Dedication* and *Success* and it decreases the *Inertia to change / to start* and *To flee*. Therefore, it can be considered that *Desire for domination / power,* taken alone, causes desirable effects in the individual and in terms of group performance. This last fact could be better understood considering as the whole group having *Desire for domination / power*. (Remembering that concepts from 1 to 36 are considered applicable to the individual and from 37 to 48 are considered applicable to the group).

Tables 8.6 and 8.8 show the effects of the concept *Inertia to change / to start* (33) taking the cases 42 and 43. This concept negatively activates 25 concepts and positively just 2 (case 33). The highest degrees of decrease occur in the concepts *Self-esteem*, *Self-confidence*, *To go on / persevere*, *To act*, *To believe in the possibility of*, *Cooperation*, *Satisfaction*, *Confidence in the group, Dedication* and *Success*. It causes an increase in itself and in the concept *To flee.* Therefore, it can be considered that *Inertia to change / to start*, taken alone, causes undesirable effects in the individual and in group performance.

Tables 8.6 and 8.9 show the effects of the concept *Introversion* (13) taking cases 44 and 45. It negatively activates 25 concepts and positively just 3 (case 44). The most meaningful decreases occur in the concepts *Motivation, Self-esteem*, *Self-confidence*, *To go on / persevere*, *To act*, *Cooperation*, *Satisfaction*, *Confidence in the group, Dedication* and *Success.* It causes an increase in the concepts *Inertia to change / to start*, *To flee* and *Individualism.* Therefore, it can be considered that *Introversion,* taken alone, causes undesirable effects in the individual and in group performance.

Table 9.1 shows another set of cases and the correspondent results are presented from Table 9.2 to Table 9.5. Cases 66 to 79 try to simulate real cases. A managing group could activate the chosen concepts to generate such situation. For example, to scold someone due to his/her lack of responsibility could activate the Concept *Guilt* (6). Then in cases 66 and 67 (Tables 9.1 and 9.2) this concept was activated to analyze the implications in the whole system. So, Table 9.2 shows correspondence to the results. It negatively activated 25 concepts and positively just 2 (Case 66 - Table 9.2). The most meaningful decreases occur in the concepts *Self-esteem*, *Self-confidence*, *To go on / persevere*, *To act*, *Cooperation*, *Satisfaction*, *Confidence in the group, Dedication* and *Success*. To a lesser extent it also causes a decrease in the concepts *Joy, Feeling of empathy, Extroversion, Desire for achievement, Desire for affiliation/association, Motivation Leisure, To be accepted, To be important/worthy, To believe in the possibility of, Planning and goals, and Organization*. It causes an increase in the concepts *Inertia to change / to start* and *To flee,* and to a lesser extent it also causes an increase in *Sadness, Frustration, Introversion, To be threatened, Individualism* and *Stress*. Therefore, to activate *Guilt* (6), taken alone, does not seem to be a good strategy. Cases 76 and 77 (Tables 9.1 and 9.3) simultaneously activate the concept *Guilt* (6) and *Punishment* (46) with +1. It negatively activated 22 concepts and positively 7 (Case 76 Table 9.3). But, in general, it can be said that the results are practically the same as those obtained with just *Guilt (6)*. The differences are subtle in the intensities of the concepts: *Sadness, Fear, Frustration, Introversion, Desire for independence, Overestimation of time, To be rewarded, To be accepted, To go on/to persevere, Individualism,* and *Stress*.

The Concept *Overestimation of time* (16) is another concept relatively easy to be activated. Table 9.1 shows the cases 68 and 69 and the results obtained with the activation of this concept are shown in Table 9.2. It negatively activates just 2 concepts and positively 24 (case 68 Table 9.2). The most meaningful increases occur in the concepts *Desire for achievement*, *Motivation*, *Self-esteem*, *Self-confidence*, *To go on / persevere*, *To act*, *To believe in the possibility of*, *Planning and goals*, *Cooperation*, *Satisfaction*, *Dedication* and *Success.* It causes a decrease in the concepts *Inertia to change / to start* and *To flee,* and to a lesser extent it also causes a decrease in *Sadness.* Therefore, to activate *Overestimation of time* (16) seems to be a good strategy, at least, without the simultaneous activation of the other concepts.

In cases 70 and 71 (Table 9.1) the concept *Leisure* (24) is activated with –1. In such cases this kind of activation could represent, for example, an excessive charge of work or professional solicitations without any leisure time. The results can be seen in cases 70 and 71 in Table 9.2. It negatively activates 25 concepts and positively just 3 (case 70 – Table 9.2). The most meaningful decreases occur in the concepts *Self-esteem*, *Self-confidence*, *To act*, *Cooperation*, *Satisfaction*, *Confidence in the group, Dedication* and *Success.* To a lesser extent it also causes a decrease in *Joy, Feeling of empathy, Extroversion, Desire for achievement, Desire for affiliation/association, Interest, Motivation, Leisure, To be accepted, To be important/worthy, To go on/to persevere, To believe in the possibility of, Planning and goals*, and *Organization.* It causes an increase in the concepts *Inertia to change / to start, To flee,* and *Individualism.* To a lesser extent it also causes an increase in *Sadness, Frustration, To be threatened,* and *Stress*. Therefore, to activate negatively the concept *Leisure* (24) it does not seem to be a good strategy.

In cases 72 and 73 (Table 9.1) the concept *To be rewarded* (25) was activated with +1. This concept can be easily activated in an enterprise, for example, with prizes or some kind of award for good performance. The results can be seen in Table 9.2, cases 72 and 73. It positively activates 24 concepts and negatively just 2 (case 72 - Table 9.2). The most meaningful increases occur in the concepts *Joy*, *Desire for achievement, Motivation, Self-esteem*, *Self-confidence*, *To go on/to persevere, To act, To believe in the possibility of, Cooperation*, *Satisfaction*, *Dedication*, and *Success.* To a lesser extent it also causes an increase in *Feeling of empathy, Extroversion, Desire for independence, Overestimation of time, Desire for affiliation/association, Interest, To be rewarded, To be accepted, To be important/worthy, Planning and goals, Organization,* and *Confidence in the group.* It causes a decrease in the concepts *Inertia to change / to start,* and *To flee*, and to a lesser extent it also causes a decrease in *Sadness and Individualism.* Therefore, to activate positively the concept *To be rewarded* (25) seems to be a good strategy, at least, taken it alone.

In cases 74 and 75 the concept *Competition* (48) is activated with +1. This concept can be easily activated in an enterprise, for example, with some kind of award to those who have had the best performance in some task in a group. The results obtained with the simulation can be seen in Table 9.2, cases 74 and 75. It positively activates 24 concepts and negatively just 2 (case 74 - Table 9.2). Except by the intensity of the first concept *Joy*, the results obtained were practically the same of those obtained with the activation of the concept *To be rewarded* (25) (cases 72 and 73, Table 9.2). And activating *Competition*

(48) and *To be rewarded* (25) simultaneously with +1 (cases 78 and 79 – Table 9.3) also obtained practically the same responses as it is shown in the Table 9.3.

Table 9.1 – Set of cases and the correspondent results are presented from Table 9.2 to Table 9.5.

Case Number	**Active Concept(s)**	**Numeric Equivalent**	**Threshold Function**	**Clamping**	**Convergence** (# iterations)
66	6)=>+1	Linear	Trivalent	Yes	10
67	6)=>+1	Linear	Septivalent	Yes	6
68	16)=>+1	Linear	Trivalent	Yes	4
69	16)=>+1	Linear	Septivalent	Yes	6
70	24)=>-1	Linear	Trivalent	Yes	5
71	24)=>-1	Linear	Septivalent	Yes	8
72	25)=>+1	Linear	Trivalent	Yes	3
73	25)=>+1	Linear	Septivalent	Yes	4
74	48)=>+1	Linear	Trivalent	Yes	5
75	48)=>+1	Linear	Septivalent	Yes	9
76	6)&46)=>+1	Linear	Trivalent	Yes	6
77	6)&46)=>+1	Linear	Septivalent	Yes	4
78	25)&48)=>+1	Linear	Trivalent	Yes	4
79	25)&48)=>+1	Linear	Septivalent	Yes	7
80	40)&42)=>-1&41)=>+1	Linear	Trivalent	Yes	4
81	40)&42)=>-1&41)=>+1	Linear	Septivalent	Yes	5
82	24)&37)&38)=>+1	Linear	Trivalent	Yes	3
83	24)&37)&38)=>+1	Linear	Septivalent	Yes	5
84	25)&37)=>+1	Linear	Trivalent	Yes	3
85	25)&37)=>+1	Linear	Septivalent	Yes	6
86	3)&10)&13)=>+1	Linear	Trivalent	Yes	4
87	3)&10)&13)=>+1	Linear	Septivalent	Yes	5
88	31)=>+1	Linear	Trivalent	Yes	14
89	31)=>+1	Linear	Septivalent	Yes	8
90	14)&31)=>+1	Linear	Trivalent	Yes	7
91	14)&31)=>+1	Linear	Septivalent	Yes	7
92	45)=>-1	Linear	Trivalent	Yes	10
93	45)=>-1	Linear	Septivalent	Yes	7
94	4)&7)&31)&48)=>+1 42)=>-1	Linear	Trivalent	Yes	4
95	4)&7)&31)&48)=>+1 42)=>-1	Linear	Septivalent	Yes	8
96	16)&20)&41)=>+1 39)=>-1	Linear	Trivalent	Yes	6
97	16)&20)&41)=>+1 39)=>-1	Linear	Septivalent	Yes	8
98	16) &45)&46) &47)=>+1	Linear	Trivalent	Yes	6
99	16) &45)&46) &47)=>+1	Linear	Septivalent	Yes	6
100	37)&38)&41)=>+1 39) &40)&42)=>-1	Linear	Trivalent	Yes	7
101	37)&38)&41)=>+1 39) &40)&42)=>-1	Linear	Septivalent	Yes	5
102	4)&19)&45) =>+1 11) &42)=>-1	Linear	Trivalent	Yes	10
103	4)&19)&45) =>+1 11) &42)=>-1	Linear	Septivalent	Yes	9
104	3) &10)&11) &13)&18)=>+1	Linear	Trivalent	Yes	6
105	3) &10)&11) &13)&18)=>+1	Linear	Septivalent	Yes	6

Table 9.2 – Results from the case 66 to 75 (see Table 9.1).

	Case →	66	67	68	69	70	71	72	73	74	75
	Concepts ↓/ Active concept →	6)+1	6)+1	16)+1	16)+1	24)-1	24)-1	25)+1	25)+1	48)+1	48)+1
In the individual	01. Joy	-1	D	+1	A	-1	D	+1	AM	+1	A
	02. Sadness	0	A	0	D	0	A	0	D	0	D
	03. Fear	0	AP	0	DP	0	AP	0	DP	0	DP
	04. Anger	0	AP	0	DP	0	AP	0	DP	0	DP
	05. Repulsion	0	AP	0	DP	0	AP	0	DP	0	DP
	06. Guilt	0	AP	0	DP	0	AP	0	DP	0	DP
	07. Envy	0	AP	0	NC	0	AP	0	NC	0	NC
	08. Jealousy	0	AP	0	NC	0	AP	0	NC	0	NC
	09. Grief	0	AP	0	DP	0	AP	0	DP	0	DP
	10. Shame	0	AP	0	DP	0	AP	0	DP	0	DP
	11. Feeling of empathy	-1	D	+1	A	-1	D	+1	A	+1	A
	12. Frustration	0	A	0	DP	0	A	0	DP	0	DP
	13. Introversion	0	A	0	DP	0	AP	0	DP	0	DP
	14. Extroversion	-1	D	+1	A	-1	D	+1	A	+1	A
	15. Desire for independence	-1	DP	+1	A	-1	DP	+1	A	+1	A
	16. Overestimation of time	-1	DP	+1	A	-1	DP	+1	A	+1	A
	17. Desire for Achievement	-1	D	+1	AM	-1	D	+1	AM	+1	AM
	18. Desire for affiliation/association	-1	D	+1	A	-1	D	+1	A	+1	A
	19. Desire for power/domination	0	NC	0	NC	0	NC	0	NC	0	NC
	20. Desire to attract attention	0	DP	0	AP	0	DP	0	AP	0	AP
	21. Interest	-1	D	+1	A	-1	D	+1	A	+1	A
	22. Desire for vengeance	0	AP	0	DP	0	AP	0	DP	0	DP
	23. Motivation	-1	D	+1	AM	-1	D	+1	AM	+1	AM
	24. Leisure	-1	D	0	A	-1	D	0	A	0	A
	25. To be rewarded	-1	DP	+1	A	-1	DP	+1	A	+1	A
	26. To be threatened	0	A	0	DP	0	A	0	DP	0	DP
	27. To be accepted	-1	D	+1	A	-1	D	+1	A	+1	A
	28. To be important / worthy	-1	D	+1	A	-1	D	+1	A	+1	A
	29. Self-esteem	-1	DM	+1	AM	-1	DM	+1	AM	+1	AM
	30. Self-confidence	-1	DM	+1	AM	-1	DM	+1	AM	+1	AM
	31. Arrogance	0	NC	0	NC	0	AP	0	NC	0	NC
	32. To go on / to persevere	-1	DM	+1	AM	-1	D	+1	AM	+1	AM
	33. Inertia to change / to start	+1	A	-1	DM	+1	A	-1	D	-1	D
	34. To act	-1	DM	+1	AM	-1	DM	+1	AM	+1	AM
	35. To flee	+1	A	-1	D	+1	A	-1	D	-1	D
	36. To believe in the possibility of	-1	D	+1	AM	-1	D	+1	AM	+1	AM
In the group	37. Planning and goals	-1	D	+1	AM	-1	D	+1	A	+1	A
	38. Organization	-1	D	+1	A	-1	D	+1	A	+1	A
	39. Cooperation	-1	DM	+1	AM	-1	DM	+1	AM	+1	AM
	40. Satisfaction	-1	DM	+1	AM	-1	DM	+1	AM	+1	AM
	41. Individualism	0	A	0	DP	+1	A	0	D	0	D
	42. Confidence in the group	-1	DM	+1	A	-1	DM	+1	A	+1	A
	43. Dedication	-1	DM	+1	AM	-1	DM	+1	AM	+1	AM
	44. Success	-1	DM	+1	AM	-1	DM	+1	AM	+1	AM
	45. Authoritarian leadership	0	AP	0	DP	0	AP	0	DP	0	DP
	46. Punishment	0	AP	0	DP	0	AP	0	DP	0	DP
	47. Stress	0	A	0	DP	0	A	0	DP	0	DP
	48. Competition	0	NC	0	NC	0	AP	0	NC	0	NC

In cases 80 and 81 (Table 9.1) the concepts *Satisfaction* (40) and *Confidence in the group* (42) were activated with –1 and *Individualism* (41) was activated with +1. Such activation tries to represent a possible real situation in a group to be analyzed: dissatisfaction, lack of confidence in the group and individualism. It negatively activates

24 concepts and positively just 3 (case 80 - Table 9.3). Such situation causes the most meaningful decreases in the concepts *Self-esteem, Self-confidence, To act, Cooperation, Satisfaction, Confidence in the group*, *Dedication* and *Success*. To a lesser extent it also causes a decrease in *Joy, Feeling of empathy, Extroversion, Desire for Achievement, Desire for affiliation/association, Interest, Motivation, Leisure, To be accepted, To be important/worthy, To go on /to persevere, To believe in the possibility of, Planning and goals,* and *Organization.* It causes an increase in the concepts *Inertia to change / to start, To flee,* and *Individualism.* To a lesser extent it also causes an increase in *Sadness, Frustration, To be threatened,* and *Stress.* Therefore, such situation provokes undesirable results in the whole system.

In the cases 82 and 83 (Table 9.1) the concepts *Leisure* (24), *Planning and goals* (37), and *Organization* (38) were activated with +1. Such activation tries to represent a possible real situation in a group/enterprise that can be provided by the administration staff. It positively activates 24 concepts and negatively just 2 (case 82 - Table 9.3). Such situation causes the most meaningful increases in the concepts *Joy, Desire for achievement, Motivation, Self-esteem, Self-confidence, To go on /to persevere, To act, To believe in the possibility of, Cooperation, Satisfaction, Confidence in the group*, *Dedication* and *Success.* It causes a decrease in the concepts *Inertia to change / to start, To flee,* and to a lesser extent, in *Sadness* and *Individualism.* Therefore, as someone could expect, the activation of these concepts bring out desirable results. Coincidently, the results obtained with the simultaneous activation of the concepts *To be reward* (25) and *Planning and goals* (37) (cases 84 and 85, Tables 9.1 and 9.3) practically got the same results. Such coincidence can be justified due to the fact that only desirable concepts have been activated. In situations like that the system response tends to settle down in a very similar condition.

Table 9.3 – Results from the case 76 to 85 (see Table 9.1).

	Case →	*76*	*77*	*78*	*79*	*80*	*81*	*82*	*83*	*84*	*85*
	Concepts ↓/ Active concept →	*6)+1 46)+1*	*6)+1 46)+1*	25) +1 48)+1	25) +1 48)+1	40)-1 41)+1 42)-1	40)-1 41)+1 42)-1	24)+1 37)+1 38)+1	24)+1 37)+1 38)+1	*25)+1 37)+1*	*25)+1 37)+1*
In the individual	01. Joy	-1	D	+1	A	-1	D	+1	AM	+1	AM
	02. Sadness	+1	A	0	D	0	A	0	D	0	D
	03. Fear	0	A	0	DP	0	AP	0	DP	0	DP
	04. Anger	0	AP	0	DP	0	AP	0	DP	0	DP
	05. Repulsion	0	AP	0	DP	0	AP	0	DP	0	DP
	06. Guilt	0	AP	0	DP	0	AP	0	DP	0	DP
	07. Envy	0	AP	0	NC	0	AP	0	NC	0	NC
	08. Jealousy	0	AP	0	NC	0	AP	0	NC	0	NC
	09. Grief	0	AP	0	DP	0	AP	0	DP	0	DP
	10. Shame	0	AP	0	DP	0	AP	0	DP	0	DP
	11. Feeling of empathy	-1	D	+1	A	-1	D	+1	A	+1	A
	12. Frustration	+1	A	0	DP	0	A	0	DP	0	DP
	13. Introversion	+1	A	0	DP	0	AP	0	DP	0	DP
	14. Extroversion	-1	D	+1	A	-1	D	+1	A	+1	A
	15. Desire for independence	0	DP	+1	A	0	DP	+1	AP	+1	AP
	16. Overestimation of time	0	DP	+1	A	-1	DP	+1	AP	+1	A
	17. Desire for Achievement	-1	D	+1	AM	-1	D	+1	AM	+1	AM
	18. Desire for affiliation/association	-1	D	+1	A	-1	D	+1	A	+1	A
	19. Desire for power/domination	O	NC	0	NC	0	AP	0	NC	0	NC
	20. Desire to attract attention	O	DP	0	AP	0	DP	0	AP	0	AP
	21. Interest	-1	D	+1	A	-1	D	+1	A	+1	A
	22. Desire for vengeance	0	AP	0	DP	0	AP	0	DP	0	DP
	23. Motivation	-1	D	+1	AM	-1	D	+1	AM	+1	AM
	24. Leisure	-1	D	0	A	-1	D	+1	A	0	A
	25. To be rewarded	0	DP	+1	A	-1	DP	+1	A	+1	A
	26. To be threatened	0	A	0	DP	0	A	0	DP	0	DP
	27. To be accepted	-1	DP	+1	A	-1	D	+1	A	+1	A
	28. To be important / worthy	-1	D	+1	A	-1	D	+1	A	+1	A
	29. Self-esteem	-1	DM	+1	AM	-1	DM	+1	AM	+1	AM
	30. Self-confidence	-1	DM	+1	AM	-1	DM	+1	AM	+1	AM
	31. Arrogance	0	NC	0	NC	0	AP	0	DP	0	DP
	32. To go on / to persevere	-1	D	+1	AM	-1	D	+1	AM	+1	AM
	33. Inertia to change / to start	+1	A	-1	DM	+1	A	-1	D	-1	D
	34. To act	-1	DM	+1	AM	-1	DM	+1	AM	+1	AM
	35. To flee	+1	A	-1	D	+1	A	-1	D	-1	D
	36. To believe in the possibility of	-1	D	+1	AM	-1	D	+1	AM	+1	AM
In the group	37. Planning and goals	-1	D	+1	A	-1	D	+1	A	+1	A
	38. Organization	-1	D	+1	A	-1	D	+1	A	+1	A
	39. Cooperation	-1	DM	+1	AM	-1	DM	+1	AM	+1	AM
	40. Satisfaction	-1	DM	+1	AM	-1	DM	+1	AM	+1	AM
	41. Individualism	+1	A	0	D	+1	A	0	D	0	D
	42. Confidence in the group	-1	DM	+1	A	-1	DM	+1	AM	+1	AM
	43. Dedication	-1	DM	+1	AM	-1	DM	+1	AM	+1	AM
	44. Success	-1	DM	+1	AM	-1	DM	+1	AM	+1	AM
	45. Authoritarian leadership	0	AP	0	DP	0	AP	0	DP	0	DP
	46. Punishment	0	AP	0	DP	0	AP	0	DP	0	DP
	47. Stress	+1	A	0	DP	0	A	0	DP	0	DP
	48. Competition	0	AP	0	NC	0	AP	0	DP	0	NC

In cases 86 and 87 (Tables 9.1 and 9.4) the concepts *Fear* (3), *Shame* (10) and *Introversion* (13) were activated with +1. This could correspond to an analysis of someone's characteristics. As it can be seen in Table 9.4, such situation positively activates 9 concepts and negatively 21 (case 86). The decreases are more significant than the increases. The most meaningful decreases occur in the concepts *Self-esteem*, *Self-confidence, To go on/to persevere, To act, Cooperation, Satisfaction, Confidence in the group, Dedication*, and *Success*. The increases occur in the concepts *Sadness, Fear, Frustration, Introversion, To be threatened, Inertia to change / to start, To flee, Individualism, and Stress.* It is interesting to notice that the activation of these emotional characteristics provoke a kind of result different from those obtained until now, more emotional factors are activated.

In cases 88 and 89 (Tables 9.1 and 9.4) the concept *Arrogance* (31) was activated with +1. Such activation just wants to try out the effect of this single concept in the whole system. Such situation causes the most meaningful decreases in the concepts *Self-esteem, Self-confidence, To act, Cooperation, Satisfaction, Confidence in the group*, *Dedication* and *Success*. To a lesser extent it also causes a decrease in *Joy, Feeling of empathy, Extroversion, Desire for Achievement, Desire for affiliation/association, Interest, Motivation, Leisure, To be accepted, To be important/worthy, To go on /to persevere, To believe in the possibility of, Planning and goals,* and *Organization.* It causes an increase in the concepts *Inertia to change / to start, To flee,* and *Individualism.* To a lesser extent it also causes an increase in *Sadness, Fear, Frustration, To be threatened, and Stress.* This result is very similar to that obtained in cases 80 and 81. On the other hand, cases 90 and 91 (Tables 9.1 and 9.4) simultaneously activate (+1) the concepts *Arrogance* (31) and

Extroversion (14). The results in these cases are very different of the last one (see Table 9.4). It positively activates 25 concepts and negatively just 2 (case 90 - Table 9.4). Such situation causes the most meaningful <u>increases</u> in the concepts *Desire for achievement*, *Motivation*, *Self-esteem, Self-confidence, To go on /to persevere, To act, To believe in the possibility of, Cooperation, Satisfaction,* and *Dedication*. To a lesser extent it can be verified the <u>increase</u> of the concepts *Joy, Feeling of empathy, Extroversion, Desire of independence, Overestimation of time, Desire for affiliation/association, Interest, Leisure, To be rewarded, To be accepted, To be important/worthy, Planning and goals, Organization, Confidence in the group, and Success*. It causes a <u>decrease</u> in the concepts *Inertia to change / to start, To flee,* and to a lesser extent, in *Sadness.* It is interesting to notice here that the effects caused by *Extroversion* (14) and *Arrogance* (31) together disguise the effects caused when this second is taken alone.

In cases 92 and 93 (Tables 9.1 and 9.4) the concept *Authoritarian leadership* (45) was activated with –1, which means to activate the logical opposite of this concept (democratic leadership? anarchist leadership?). It positively activates 25 concepts and negatively just 3 (case 92 - Table 9.4). Table 9.4 shows the obtained results. The most meaningful <u>increases</u> occur in the concepts *Self-esteem*, *Self-confidence*, *To act, Cooperation*, *Satisfaction*, *Confidence in the group Dedication*, and *Success.* To a lesser extent it also causes an <u>increase</u> in *Joy*, *Feeling of empathy, Extroversion, Desire for achievement, Desire for affiliation/association, Interest, Motivation, Leisure, To be accepted, To be important/worthy, To go on/ to persevere, To believe in the possibility of, Planning and goals,* and *Organization.* It causes a <u>decrease</u> in the concepts *Inertia to change / to start, To flee,* and *Individualism.* To a lesser extent it also causes a <u>decrease</u> in

Sadness, Fear, Frustration, To be threatened, and *Stress.* Therefore, to activate negatively the concept *Authoritarian leadership* (45) with –1 produces desirable results in the individual and in the group.

Table 9.4 – Results from the case 86 to 95 (see Table 9.1).

	Case →	*86*	*87*	*88*	*89*	*90*	*91*	*92*	*93*	*94*	*95*
	Concepts ↓/ Active concept →	*3)+1 10)+1 13)+1*	*3)+1 10)+1 13)+1*	31)+1	31)+1	14)+1 31)+1	14)+1 31)+1	45) -1	45)-1	*4)+1 7)+1 31)+1 48)+1 42)-1*	*4)+1 7)+1 31)+1 48)+1 42)-1*
In the individual	01. Joy	-1	D	-1	D	+1	A	+1	A	-1	D
	02. Sadness	+1	A	0	A	0	D	0	D	+1	A
	03. Fear	+1	A	0	A	0	DP	0	D	+1	A
	04. Anger	0	AP	0	AP	0	DP	0	DP	+1	A
	05. Repulsion	0	AP	0	AP	0	DP	0	DP	+1	AP
	06. Guilt	0	AP	0	AP	0	DP	0	DP	0	AP
	07. Envy	0	AP	0	AP	0	NC	0	DP	0	AP
	08. Jealousy	0	AP	0	AP	0	NC	0	DP	0	AP
	09. Grief	0	AP	0	AP	0	DP	0	DP	+1	A
	10. Shame	0	AP	0	AP	0	DP	0	DP	0	AP
	11. Feeling of empathy	-1	D	-1	D	+1	A	+1	A	-1	D
	12. Frustration	+1	A	0	A	0	DP	0	D	+1	A
	13. Introversion	+1	A	0	AP	0	DP	0	DP	0	AP
	14. Extroversion	-1	D	-1	D	+1	A	+1	A	0	D
	15. Desire for independence	0	DP	0	DP	+1	A	+1	AP	0	DP
	16. Overestimation of time	0	DP	-1	DP	+1	A	+1	AP	0	DP
	17. Desire for Achievement	-1	D	-1	D	+1	AM	+1	A	0	D
	18. Desire for affiliation/association	-1	D	-1	D	+1	A	+1	A	-1	D
	19. Desire for power/domination	0	NC	0	AP	0	NC	0	DP	+1	AP
	20. Desire to attract attention	0	DP	0	NC	0	AP	0	NC	0	NC
	21. Interest	-1	D	-1	D	+1	A	+1	A	0	D
	22. Desire for vengeance	0	AP	0	AP	0	DP	0	DP	+1	AP
	23. Motivation	-1	D	-1	D	+1	AM	+1	A	0	D
	24. Leisure	-1	D	-1	D	+1	A	+1	A	-1	D
	25. To be rewarded	0	DP	-1	DP	+1	A	+1	AP	0	DP
	26. To be threatened	+1	A	0	A	0	DP	0	D	+1	A
	27. To be accepted	0	DP	-1	D	+1	A	+1	A	0	DP
	28. To be important / worthy	-1	D	-1	D	+1	A	+1	A	0	D
	29. Self-esteem	-1	DM	-1	DM	+1	AM	+1	AM	-1	DM
	30. Self-confidence	-1	DM	-1	DM	+1	AM	+1	AM	-1	DM
	31. Arrogance	0	NC	0	AP	0	NC	0	DP	+1	AP
	32. To go on / to persevere	-1	DM	-1	D	+1	AM	+1	A	0	D
	33. Inertia to change / to start	+1	A	+1	A	-1	D	-1	D	0	A
	34. To act	-1	DM	-1	DM	+1	AM	+1	AM	0	D
	35. To flee	+1	A	+1	A	-1	D	-1	D	0	A
	36. To believe in the possibility of	-1	D	-1	D	+1	AM	+1	A	0	D
In the group	37. Planning and goals	-1	D	-1	D	+1	A	+1	A	0	D
	38. Organization	-1	D	-1	D	+1	A	+1	A	0	D
	39. Cooperation	-1	DM	-1	DM	+1	AM	+1	AM	-1	DM
	40. Satisfaction	-1	DM	-1	DM	+1	AM	+1	AM	-1	DM
	41. Individualism	+1	A	+1	A	0	DP	-1	D	+1	A
	42. Confidence in the group	-1	DM	-1	DM	+1	A	+1	AM	-1	DM
	43. Dedication	-1	DM	-1	DM	+1	AM	+1	AM	-1	DM
	44. Success	-1	DM	-1	DM	+1	A	+1	AM	-1	DM
	45. Authoritarian leadership	0	AP	0	AP	0	DP	0	DP	+1	A
	46. Punishment	0	AP	0	AP	0	DP	0	DP	+1	AP
	47. Stress	+1	A	0	A	0	DP	0	D	+1	A
	48. Competition	0	NC	0	AP	0	NC	0	DP	+1	AP

Cases 94 and 95 (Tables 9.1 and 9.4) correspond to simultaneous activation of the concepts *Anger* (4), *Envy* (7), *Arrogance* (31), and *Competition* (48) with +1 and *Confidence in the group* (42) with –1. This situation could correspond to an analysis of group characteristics in some time. It positively activates 15 concepts and negatively 11 (case 94 - Table 9.4). The most meaningful decreases occur in the concepts *Self-esteem*, *Self-confidence, Cooperation, Satisfaction, Confidence in the group, Dedication*, and *Success*. To a lesser extent it also causes a <u>decrease</u> in *Joy, Feeling of empathy, Desire for affiliation / association,* and *Leisure.* The <u>increases</u> occur in the concepts *Sadness, Fear, Anger, Grief, Frustration, To be threatened, Individualism, Authoritarian leadership and Stress.* It is interesting to note that such situation activates more emotional factors than others already analyzed. In addition, the positive action of *Competition,* taken alone, (see cases 74 and 75) was disguised by the action of the other concepts.

Cases 96 and 97 (Tables 9.1 and 9.5) correspond to simultaneous activation of the concepts *Overestimation of time* (16), *Desire to attract attention* (20), and *Individualism* (41) with +1 and *Cooperation* (39) with –1. This case could correspond to an analysis of some people's characteristics in a given period of time. It positively activates 6 concepts and negatively 8 (case 96 - Table 9.5). The most meaningful <u>decreases</u> occur in the concepts *Cooperation*, *Satisfaction, Confidence in the group, Dedication*, and *Success*. The concepts *Self-esteem, Self-confidence,* and *To act* appeared as "much decrease" just in the case 97 (Septivalent). To a lesser extent it causes a <u>decrease</u> in *Joy, Feeling of empathy, and Desire for affiliation/association*. The <u>increases</u> occur in the concepts *Individualism* and *Stress.* To a lesser extent it causes an <u>increase</u> in *Sadness, Fear, Frustration, Introversion, To be threatened, Inertia to change/ to start*, and *To flee*. The positive action of *Overestimation of time,* taken alone, (cases 68 and 69) was disguised by the action of the other concepts. It is interesting to notice that for these cases there are more discrepancies between Trivalent and Septivalent threshold function responses than in prior cases. The analysis made here took simultaneously into account the responses of both cases (97/98) just interpreting those extensively matched.

In cases 98 and 99 (Tables 9.1 and 9.5) the concepts *Overestimation of time* (16), *Authoritarian Leadership* (45), *Punishment* (46), and *Stress* (47) were activated with +1. Such activation tries to represent a possible real situation in a group. It positively activates 9 concepts and negatively 21 (case 98 - Table 9.5). The most meaningful decreases occur in the concepts *Self-esteem, Self-confidence, Cooperation*, *Satisfaction, Confidence in the group, Dedication*, and *Success*. To a lesser extent it causes a decrease in *Joy, Feeling of empathy, Extroversion, Desire for achievement, Desire for affiliation/association, Interest, Motivation, Leisure, To be important/worthy, To go on/to persevere, To act, To believe in the possibility of, Planning and goals,* and *Organization.* The increases occur in the concepts *Sadness, Fear, Frustration, Introversion, To be threatened, Inertia to change/to start, To flee, Individualism* and *Stress.* It is interesting to notice that case 99 (Septivalent) almost entirely matched with case 97 (Septivalent), in spite of case 96 (Trivalent) being mismatched with case 98 (Trivalent).

In cases 100 and 101 (Tables 9.1 and 9.5) the concepts *Planning and goals* (37), *Organization* (38), *Individualism* (41) were activated with +1 and *Cooperation* (39), *Satisfaction* (40) and *Confidence in the group* (42) were activated with –1. Such activation tries to represent a possible real situation in a group: organization and planning but also individualism, lack of confidence in the group and cooperation. It negatively activates 24 concepts and positively 4 (see Table 9.5 case 100). Such situation causes the most meaningful decreases in the concepts *Self-esteem, Self-confidence, To act, Cooperation, Satisfaction, Confidence in the group*, *Dedication* and *Success*. To a lesser extent it also causes a decrease in *Joy, Feeling of empathy, Extroversion, Desire for Achievement, Desire for affiliation/association, Interest, Motivation, Leisure, To be accepted, To be important/worthy, To go on /to persevere, To believe in the possibility of,* and curiously *Planning and goals* and *Organization.* It causes an increase in the concepts *Sadness*, *Inertia to change / to start, To flee,* and *Individualism.* To a lesser extent it also causes an increase in *Frustration, Introversion, To be threatened, and Stress.* Therefore, according to these results, even positively having activated *Planning and goals* and *Organization*, *Individualism,* lack of *Cooperation* and *Confidence in the group* disguised the positive action of the two first.

In cases 102 and 103 (Tables 9.1 and 9.5) the concepts *Anger* (4), *Desire for power/domination* (19) and *Authoritarian leadership* (45) were activated with +1 and *Feeling of empathy* (11) and *Confidence in the group* (42) were activated with –1. Such activation tries to represent possible features of a person. It negatively activates 22 concepts and positively 6 (case 102 - Table 9.5). Such situation causes the most meaningful decreases in the concepts *Self-esteem, Self-confidence, Cooperation, Satisfaction, Confidence in the group*, *Dedication* and *Success*. To a lesser extent it also causes a decrease in *Joy, Feeling of empathy, Extroversion, Desire for Achievement, Desire for affiliation/association, Interest, Motivation, Leisure, To be accepted, To be important/worthy, To go on /to persevere, To act, To believe in the possibility of, Planning* *and goals* and *Organization.* It causes an increase in the concepts *Sadness*, *To be threatened, Inertia to change / to start, To flee, Individualism* and *Stress.* To a lesser extent it also causes an increase in *Fear* and *Frustration.* These results are similar to those that were obtained in cases 100 and 101 (Table 9.5).

In cases 104 and 105 (Tables 9.1 and 9.5) the concepts *Fear* (3), *Shame* (10), *Feeling of empathy* (11), *Introversion* (13) and *Desire for affiliation/association* (18) were activated with +1. Such activation tries to represent possible features of a person and their influences on the whole system. It negatively activates 20 concepts and positively 9 (case 104 - Table 9.5). Such situation causes the most meaningful decreases in the concepts *Self-esteem, Self-confidence, To go on/ to persevere, To act, Cooperation, Satisfaction, Dedication* and *Success*. To a lesser extent it also causes a decrease in *Joy, Feeling of empathy, Extroversion, Desire for Achievement, Interest, Motivation, Leisure, To be important/worthy, To believe in the possibility of, Planning and goals, Organization,* and *Confidence in the group.* It causes an increase in the concepts *Sadness*, *Fear*, *Frustration*, *Introversion*, *To be threatened, Inertia to change / to start, To flee, Individualism* and *Stress.* Therefore, in spite of *Feeling of empathy* and *Desire for affiliation/association* being desirable features of someone in a social environment, if these are placed together with *Introversion* and the emotions *Fear* and *Shame*, they activates undesirable results in the whole system.

Table 9.5 – Results from the case 96 to 105 (see Table 9.1).

	Case →	*96*	*97*	*98*	*99*	*100*	*101*	*102*	*103*	*104*	*105*
	Concepts ↓/ Active concept →	*16)+1 20)+1 39)-1 41)+1*	*16)+1 20)+1 39)-1 41)+1*	16)+1 45)+1 46)+1 47)+1	16)+1 45)+1 46)+1 47)+1	37)+1 38)+1 39)-1 40)-1 41)+1 42)-1	37)+1 38)+1 39)-1 40)-1 41)+1 42)-1	*4)+1 11)-1 19)+1 42)-1 45)+1*	*4)+1 11)-1 19)+1 42)-1 45)+1*	*3)+1 10)+1 11)+1 13)+1 18)+1*	*3)+1 10)+1 11)+1 13)+1 18)+1*
In the individual	01. Joy	-1	D	-1	D	-1	D	-1	D	-1	D
	02. Sadness	0	A	+1	A	+1	A	+1	A	+1	A
	03. Fear	0	A	+1	A	0	AP	0	A	+1	A
	04. Anger	0	AP	0	A	0	AP	0	AP	0	AP
	05. Repulsion	0	AP	0	AP	0	AP	0	AP	0	AP
	06. Guilt	0	AP	0	AP	0	AP	0	AP	0	AP
	07. Envy	0	AP	0	AP	0	AP	0	AP	0	AP
	08. Jealousy	0	AP	0	AP	0	AP	0	AP	0	AP
	09. Grief	0	AP	0	AP	0	AP	0	AP	0	AP
	10. Shame	0	AP	0	AP	0	AP	0	AP	0	AP
	11. Feeling of empathy	-1	D	-1	D	-1	D	-1	D	-1	D
	12. Frustration	0	A	+1	A	0	A	0	A	+1	A
	13. Introversion	0	A	+1	A	0	A	0	AP	+1	A
	14. Extroversion	0	D	-1	D	-1	D	-1	D	-1	D
	15. Desire for independence	0	DP	0	DP	0	DP	0	DP	0	DP
	16. Overestimation of time	0	DP	0	DP	-1	DP	0	DP	0	DP
	17. Desire for Achievement	0	D	-1	D	-1	D	-1	D	-1	D
	18. Desire for affiliation/association	-1	D	-1	D	-1	D	-1	D	0	D
	19. Desire for power/domination	+1	AP	0	AP	0	AP	0	AP	0	NC
	20. Desire to attract attention	0	NC	0	NC	0	DP	0	NC	0	DP
	21. Interest	0	D	-1	D	-1	D	-1	D	-1	D
	22. Desire for vengeance	0	AP	0	AP	0	AP	0	AP	0	AP
	23. Motivation	0	D	-1	D	-1	D	-1	D	-1	D
	24. Leisure	0	D	-1	D	-1	D	-1	D	-1	D
	25. To be rewarded	0	DP	0	DP	-1	DP	0	DP	0	DP
	26. To be threatened	0	A	+1	A	0	A	+1	A	+1	A
	27. To be accepted	0	D	0	DP	-1	D	-1	D	0	DP
	28. To be important / worthy	0	D	-1	D	-1	D	-1	D	-1	D
	29. Self-esteem	0	DM	-1	DM	-1	DM	-1	DM	-1	DM
	30. Self-confidence	0	DM	-1	DM	-1	DM	-1	DM	-1	DM
	31. Arrogance	+1	AP	0	AP	0	AP	0	AP	0	NC
	32. To go on / to persevere	0	D	-1	D	-1	D	-1	D	-1	DM
	33. Inertia to change / to start	0	A	+1	A	+1	A	+1	A	+1	A
	34. To act	0	DM	-1	D	-1	DM	-1	D	-1	DM
	35. To flee	0	A	+1	A	+1	A	+1	A	+1	A
	36. To believe in the possibility of	0	D	-1	D	-1	D	-1	D	-1	D
In the group	37. Planning and goals	0	D	-1	D	-1	D	-1	D	-1	D
	38. Organization	0	D	-1	D	-1	D	-1	D	-1	D
	39. Cooperation	-1	DM	-1	DM	-1	DM	-1	DM	-1	DM
	40. Satisfaction	-1	DM	-1	DM	-1	DM	-1	DM	-1	DM
	41. Individualism	+1	A	+1	A	+1	A	+1	A	+1	A
	42. Confidence in the group	-1	DM	-1	DM	-1	DM	-1	DM	-1	D
	43. Dedication	-1	DM	-1	DM	-1	DM	-1	DM	-1	DM
	44. Success	-1	DM	-1	DM	-1	DM	-1	DM	-1	DM
	45. Authoritarian leadership	+1	AP	0	AP	0	AP	0	AP	0	AP
	46. Punishment	0	AP	0	AP	0	AP	0	AP	0	AP
	47. Stress	+1	A	+1	A	0	A	+1	A	+1	A
	48. Competition	+1	AP	0	AP	0	AP	0	AP	0	NC

9.3 Conclusions

Several cases have been tested to assess the FCM system's conduct. The results have been analyzed in order to infer the evoked potential of psychological reality. Based on *common sense* experiences, it can be considered that the results have demonstrated, to some extent, coherence with expected outcomes. Indeed, the system simulations brought out the experts' beliefs, i.e., their thoughts about how concepts are interlinked. Due to the great number of links, some experts' beliefs will just become known as an FCM "hidden pattern", which are possibly related to unconscious beliefs. The outcome gives us clues on what happens in a situation according to the experts' viewpoint.

This chapter has performed an analysis of interaction among the concepts. This is the main goal of the FCM technique and also the most important purpose in this research. It has particularly tested two kinds of cases: the analysis of the influence of a single concept on the others, and the activation of a set of concepts representing a specific situation. It was shown that sometimes the influence of a concept is disguised by another concept. Also, for the cases tested here, there are two points in which the system often settles down: desirable influence and undesirable influence. Based on *common sense* thoughts, it has been assumed that the it will be analyzed desirable influence in the system consists of the positive activation of the concepts: *Joy, Feeling of empathy, To go on / to persevere, To act, Self-esteem, Self-confidence, Desire for achievement, Interest, Motivation, Planning and goals, Organization, Cooperation, Satisfaction, Confidence in group, Dedication* and *Success*. On the other hand, undesirable influence here means to activate positively the concepts: *Sadness, Envy, Jealousy, Grief, Shame, Frustration, Desire for vengeance, To be threatened, Arrogance, Inertia to change / start, To flee,* *Individualism*, and *Stress*. It was verified here that these types of influence work somewhat in opposition, that means, when one increases the other decreases and vice versa. The level of activation of those concepts can be a little different and the other ones, which were not cited above, can vary for each case tested. In spite of some differences particular to each case, the outcomes showed a tendency for polarization – desirable or undesirable.

The feature of the outcomes shows, in addition to common tools used in Psychology research such as statistical analysis and *psychological tests*, that the FCM modeling could also be applied allowing inferences and predictions about related questions. Thus, as what happens with the other tools, it would facilitate additional objectiveness in dealing with subjects in Psychology. It can offer specialists many clues to make easier to understand the psychological reality (individual, social, and decision-making process) and also to reflect on their own beliefs.

Chapter 10

CONCLUSION AND SUGGESTIONS FOR FURTHER RESEARCH

This work has presented all theoretical foundations and practical experiments to justify "An artificial model of cognitive, emotional and motivational processes using Fuzzy Cognitive Maps". The most important questions have been deeply explored to attend high scientific level that is required in such kind of research.

Chapter 2 has reviewed the cognitive approaches of emotion and cognition. Cognitive approaches regard human beings as information processors. From this point of view, emotion and motivation are just facets of the whole information system, which are responsible for the adaptation of the body and direction of behavior. Such approaches have pointed out some cognitive constructs like goals, plans, motives, expectancy, personality traits, etc. as important parts of the emotional and motivational processes. These cognitive constructs are complex structures of knowledge that are not enough understood yet. Psychology has seen this subject in a high level of abstraction and conceptual generalization, and, in the majority of the models, in a sequential fashion. However, Power and Dalgleish [PwD97] have emphasized the necessity of more parallel and integrative models. On the other hand, nowadays Artificial Intelligence has developed artificial models of robots or softbots (software like robots) that by means of algorithms and automatic mechanisms have some kind of emotional behavior. Such simulations basically transcribe a psychological model into a computational implementation. Thus, the limitations of the psychological models persist, with many constraints, in artificial models. Chapter 3 has reviewed artificial approaches of cognition and emotion.

Traditionally, statistical tools are often used in Experimental Psychology to get more objective conclusions about the reality of the mind. Currently, several other mathematical tools have been developed as a new way to deal with imprecision, ill-defined questions, uncertainties, etc, but they still are practically unknown in Psychology. Fuzzy Logic is an example of such new tools. It is very useful for dealing with linguistic information and qualitative reasoning. Fuzzy Cognitive Maps – FCMs- is also a new tool that places Fuzzy Logic and Neural networks features together. In FCMs the nodes are fuzzy sets and edges are links among the nodes represented as fuzzy variables. These last characteristics are also desired to represent mental processing. Thus, FCMs have a great potential to simulate psychological reality as it was explained in details in Chapter 4.

Chapter 5 has described how cognitive, emotional, and motivational processes can be represented as an FCM. It takes into account that a concept (a node in the FCM) is expressed by *words* or *linguistic expressions*, which, in someone's mind, hides a net of multi-modal (sensorial and semantic) information. Such net integrates information in some idiosyncratic pattern of similarity forming a mental representation about something. A mental representation can be activated by several kinds of information, but the linguistic fashion is one of the shortest ways to code due to its capacity of abstraction and generalization. From a computational perspective, linguistic fashion is easier to deal with than sensorial images and fuzzy causal relations can represent interconnections among the concepts. These interconnections simulate parallelism and concurrence as in mental processing. Another point is the facility, quickness, and flexibility in FCM modeling in comparison with other techniques. A first model can be easily proposed and, if necessary, other more complex information can be aggregated (or taken out) generating a broader (or shorter) and more exact description of the (mental) reality.

Chapters 6 and 7 have described the methodology and implementation proposed to carry out this research. A questionnaire was defined and applied to a group of psychologists. The responses collect through the questionnaire were processed to find out the causal relation among the chosen concepts. All the possible two-by-two causal relations were inspected generating a total of 2304 combinations. The average of these combinations represent the edges of the FCM connection matrix. The software developed, the numeric approximations and the simulation process have been discussed and practical issues explained and justified.

Chapter 8 has described an exploratory analysis of the data collection, of some tests that were performed, and of numeric results obtained. The exploratory analysis of the data collection has shown a profile of the experts' responses providing a qualitative idea about them. The tests aimed at assessing how the different numeric parameters influence the outcome tendencies. The results have indicated a somewhat independence of the system behavior in relation to the choice of the numeric parameters.

Finally Chapter 9 has analyzed the interaction among the concepts. This point is the main goal of the FCM technique and also the most important purpose in this research. Several cases have been suggested to evaluate the behavior of the FCM system in order to know how a concept or a set of concepts influences the entire system. The most meaningful results have been stressed with the aim of interpreting the possible psychological reality that was evoked. The obtained results have shown quite coherence with expected outcomes based on common sense experiences. In fact, the proposed FCM system expresses a synthesis of the experts' beliefs about the relationship among the concepts. The system simulations brought out the experts' beliefs, i.e., how they deem that the concepts are interweaved. Some experts' beliefs are consciously known for them but other ones are a kind of "hidden pattern" probably related to unconscious beliefs. The results give clues to understand what is going on in a situation according to the experts' standpoint.

The originality of this doctoral dissertation can be divided in three main aspects: 1) *mental representation modeled as fuzzy set*, 2) *modeling of concurrence among complex mental representations*, and 3) *the use of FCM as a model of cognitive, emotional, and motivational processes*.

1) *Mental representation modeled as fuzzy set*. Mental representations have not been yet modeled as a fuzzy set. There are several psychological approaches to memory, knowledge, and mental representation, etc. Indeed such approaches are facets of the same question, that is, the storage and organization of information in someone's mind. Seeing such organization of information as fuzzy sets it is possible to take them as several sets belonging to broader ones (more general and abstracts) and also having a *power set* (subsets). Sets can share subsets and/or some subsets can be included in another broader one. This idea makes it flexible to operate many combinations among sets and subsets representing different facets of knowledge organization in psychological level. Another point is the vagueness and lack of precise boundary that Fuzzy Sets allow simulating. Certainly mental representations have these fuzzy features but until now they have not been seen or explored from this perspective.

2) *Modeling of concurrence among complex mental representations* means to deal with complex structures of knowledge interconnected as a neural network. According to Power and Dalgleish [PwD97], the PDP (Neural Networks) approach *provides a better framework for the brain and low-level automatic processes*. But low-level automatic processes are specially related to pattern recognizing of sensorial information. Mental processing puts low-level automatic processes and high-level controlled processes together. High-level controlled processes operate with elaborate structures of information with elevated levels of abstraction and generalization. The nodes of FCM can stand for simple or complex mental representations that are associated with other ones creating a net as a neural network. But FCM nets can work in higher levels of complexity than an ordinary neural network.

3) *Use of FCM to model of cognitive, emotional, and motivational processes*. FCMs have not been used to represent the integration among the cognitive, emotional, and motivational processes until now. Hashimoto and Yamaguchi [HtY97] proposed an emotional agent in which emotional behaviors are the nodes of an FCM. However, this model allows few emotional behaviors that working in a low-level of complexity.

The third aspect has a great intersection with the second one (mentioned above), although they present some differences. FCMs are able to represent several kinds of organization, and in terms of psychological systems, many models using FCMs could be proposed operating in higher or lower levels of complexity. Thus, the proposed FCM is just one possible psychological modeling using this tool. Cognitive approaches have especially pointed out some cognitive constructs like goals, plans, motives, expectancy, and personality traits as important parts of the emotional and motivational processes. These constructs work together generating complex behaviors. Based on such conception, this research has defined classes of concepts related to emotional and motivational processing and a specific context. The particularity of the proposed modeling has been used to define the classes of concepts and their instances. The instances are the nodes of FCM and the edges among them are obtained by experts' questionnaire responses.

Also, this approach is *non-trivial* because it considers not just a computational model based on a specific psychological theory of emotion and motivation, but a new fashion of conceiving this subject. The majority of the artificial models of these issues have held their theoretical support in one or some few psychological approaches. Here this modeling is supported by the comprehensive review based on Cognitive Theories shown in Chapter 2. The perspective of Fuzzy Set and Fuzzy Logic and Neural Networks to analyze psychological questions becomes a new contribution in Psychology. In fact Fuzzy Logic seems to suit very well the psychological reality due to its capacity to deal with linguistic variables. The concepts (fuzzy sets in the FCM), stated by means of words or linguistic expressions, hide a net of associated information. Verbally expressed fuzzy sets include several subsets of information (sensorial and semantic) related to their meaning(s). Also, an FCM works approximately as Neural Network giving the model parallelism and distribution of information, as it was previously mentioned.

Another point to be considered as *non-trivial* is the fact that the model opens computational possibilities to simulate this issue in an easier and quicker way. Artificial Intelligence has been looking for psychological models computationally feasible. Ortony et al. [OCC88] proposed a model (see Chapter 2) that suits this need, but it can be considered as sequential and incomplete. Pfeifer [Pff88] and Sloman [Slm97] [Slm98] [SaL98] also defined characteristics to develop emotional behavior in computational environments but these suggestions are also partial and insufficiently clear. Another problem that also makes difficult for artificial modeling based on psychological approaches is the lack of a unified language in Psychology. These facts hinder a better comprehension of the mental reality and its simulation. Through an FCM approach the concepts of a specific psychological theory could be defined and related to others belonging to a different theory.

The encompassment of this model is large because it could be directly applied or even adapted to be useful in several contexts. The power of *representativeness* of this tool allows making flexible its application to correlated areas. Keeping the seven proposed classes of concepts, it would be possible to change some of their instances and even to change some classes to adapt for a particular purpose. It could be used as planning, diagnosis, and prediction techniques in schools, companies, therapy, etc. The investigation of the “hidden patterns” in FCMs can show relations among concepts or situations that were previously unknown. Moreover, the flexibility of the modeling with FCMs allows simulating learning or adaptability by means of changing concepts or even the weight of the edges. For those reasons, this model as it is or suited to different circumstances, might be very useful in many applications in psychology and social environment analysis. Thus, in addition to statistical analysis and *psychological tests*, which are ordinary tools on research in Psychology, the FCM technique could also be applied in order to help coping with subjects of this science with further objectiveness. It can offer experts a lot of clues to aid in the understanding of the psychological reality (individual, social, and decision-making process) and also their own beliefs. According to Kosko [Ksk91] the FCM connection matrix indeed expresses the experts' structure of beliefs about that theme, his/her biases, prejudice, wisdom, knowledge or ignorance.

Reliability, *extent*, and *limitations* of this modeling rely on how much significant are the chosen concepts to express the reality to be investigated. A concept encompasses idiosyncratic constructs and common social meaning, which are associated respectively with its vague (imprecision) and its objective (precision) features. Fuzzy modeling by means of linguistic variables (concepts) tries to mirror the reality to be analyzed. So, the concepts have to suitably represent such reality. Consequently the *reliability*, *extent*, and *limitations* of this tool depend on the degree of *representativeness* of the concepts, as well as the experts' ability of understanding and interpreting the numeric or fuzzy outcomes.

For future research it can be suggested:

- To develop a friendly interface for the software making its use for the users easier.
- To include in the software mechanisms of learning and adaptation allowing to change the concepts (adding or taking off) or the weights of the edges.
- To test different applications keeping the 7 classes, but to choose concepts and their number that are more meaningful for that situation.
- To apply this tool to particular environments (school/companies) in planning or diagnosis of problems and to assess its performance.
- To apply this tool in psychological clinics as a way to record the patients characteristics (personality, emotional and motivational aspects) to get clues of

guidance of the therapeutic proceedings. The psychologist could construct an FCM or ask the patient to fill a questionnaire. In this case the chosen concepts have to be quite meaningful for the patients.

- To search other numeric treatments to get the FCM connection matrix.
- When possible, to define the concepts with the very people those are going to answer the questionnaire (or draw a digraph) in order to get more *representativeness*.
- To use this tool to define emotional behaviors in artificial agents.

This tool allows a quick first glance approach of issues or a long and detailed one. A quick approach can be made through a digraph schematized by the people involved using few concepts. A long and detailed approach could use more concepts and spend much more time to be elaborated. Due to the higher number of combinations in this second case, the "hidden patterns" are less accessible and a computational treatment of the data is required. The advantage of this latter is to make difficult to those who answers to disguise his/her own beliefs.

Finally, the obtained results allow concluding that this modeling synthesizes a new outlook of cognition, emotion and motivation and it is able to simulate psychological processes making inferences and prediction about several issues possible. Thus, taking into account the ideas latter mentioned, the great theoretical support shown in this document, and innovative character in dealing with such interdisciplinary subject, it can be concluded that this work provides a new and powerful tool for research in Psychology and Cognitive Science.

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Appendix A

QUESTIONNAIRE

This appendix presents the material that was handed over to the experts. Figure A1 shows a schematic representation of the questionnaire applied, followed by the directions (in Portuguese) and a glossary of the concepts included for better understanding.

48. **A *COMPETIÇÃO* CAUSA …**

	Nº		NC	AM	A	AP	DM	D	DP
	01	… ALEGRIA?	NC	*AM*	A	P	DM		DP
	02	**… TRISTEZA?**	NC	AM	A	AP	DM	D	DP
	03	**… MEDO?**	NC	AM	A	AP	DM	D	DP
	04	**… RAIVA?**	NC	AM	A	AP	DM	D	DP

1. **A *ALEGRIA* CAUSA …**

	Nº		NC	AM	A	AP	DM	D	DP
NO PRÓPRIO INDIVÍDUO	*01*	… ALEGRIA?	NC	*AM*	A	P	DM		DP
	02	**… TRISTEZA?**	NC	AM	A	AP	DM	D	DP
	03	**… MEDO?**	NC	AM	A	AP	DM	D	DP
	04	**… RAIVA?**	NC	AM	A	AP	DM	D	DP
	05	**… REPULSA?**	NC	AM	A	AP	DM	D	DP
	06	**… CULPA?**	NC	AM	A	AP	DM	D	DP
	07	**… INVEJA?**	NC	AM	A	AP	DM	D	DP
	08	**… CIÚME?**	NC	AM	A	AP	DM	D	DP
	09	**… MÁGOA?**	NC	AM	A	AP	DM	D	DP
	10	**… VERGONHA?**	NC	AM	A	AP	DM	D	DP
	11	**… SENTIMENTO DE EMPATIA?**	NC	AM	A	AP	DM	D	DP
	12	**… FRUSTRAÇÃO?**	NC	AM	A	AP	DM	D	DP
	13	**… INTROVERSÃO?**	NC	AM	A	AP	DM	D	DP
	14	**… EXTROVERSÃO?**	NC	AM	A	AP	DM	D	DP
	15	**… DESEJO DE INDEPENDÊNCIA?**	NC	AM	A	AP	DM	D	DP
	16	**… SUPERVALORIZAÇÃO DO TEMPO?**	NC	AM	A	AP	DM	D	DP
	17	**… DESEJO DE REALIZAR?**	NC	AM	A	AP	DM	D	DP
	18	**… DESEJO DE AFILIAÇÃO / ASSOCIAÇÃO?**	NC	AM	A	AP	DM	D	DP
	19	**… DESEJO POR PODER / DOMINAÇÃO?**	NC	AM	A	AP	DM	D	DP
	20	**… DESEJO DE ATRAIR ATENÇÃO?**	NC	AM	A	AP	DM	D	DP
	21	**… INTERESSE / CURIOSIDADE?**	NC	AM	A	AP	DM	D	DP
	22	**… DESEJO DE VINGANÇA?**	NC	AM	A	AP	DM	D	DP
	23	**… MOTIVAÇÃO?**	NC	AM	A	AP	DM	D	DP
	24	**… LAZER?**	NC	AM	A	AP	DM	D	DP
	25	**… SER RECOMPENSADO?**	NC	AM	A	AP	DM	D	DP
	26	**… SER / ESTAR AMEAÇADO?**	NC	AM	A	AP	DM	D	DP
	27	**… SER ACEITO?**	NC	AM	A	AP	DM	D	DP
	28	**… SER IMPORTANTE / TER VALOR?**	NC	AM	A	AP	DM	D	DP
	29	**… AUTOESTIMA?**	NC	AM	A	AP	DM	D	DP
	30	**… AUTOCONFIANÇA?**	NC	AM	A	AP	DM	D	DP
	31	**… ARROGÂNCIA?**	NC	AM	A	AP	DM	D	DP
	32	**… PROSSEGUIR / PERSEVERAR?**	NC	AM	A	AP	DM	D	DP
	33	**… INÉRCIA PARA INICIAR / MUDAR?**	NC	AM	A	AP	DM	D	DP
	34	**… AGIR?**	NC	AM	A	AP	DM	D	DP
	35	**… FUGIR?**	NC	AM	A	AP	DM	D	DP
	36	**… CRER NA POSSIBILIDADE DE ?**	NC	AM	A	AP	DM	D	DP
NO GRUPO	*37*	**… PLANEJAMENTO E METAS?**	NC	AM	A	AP	DM	D	DP
	38	**… ORGANIZAÇÃO?**	NC	AM	A	AP	DM	D	DP
	39	**… COOPERAÇÃO?**	NC	AM	A	AP	DM	D	DP
	40	**… SATISFAÇÃO?**	NC	AM	A	AP	DM	D	DP
	41	**… INDIVIDUALISMO?**	NC	AM	A	AP	DM	D	DP
	42	**… CONFIANÇA NO GRUPO?**	NC	AM	A	AP	DM	D	DP
	43	**… DEDICAÇÃO?**	NC	AM	A	AP	DM	D	DP
	44	**… SUCESSO?**	NC	AM	A	AP	DM	D	DP
	45	**… LIDERANÇA AUTORITÁRIA?**	NC	AM	A	AP	DM	D	DP
	46	**… PUNIÇÃO?**	NC	AM	A	AP	DM	D	DP
	47	**… ESTRESSE?**	NC	AM	A	AP	DM	D	DP
	48	**… COMPETIÇÃO?**	NC	AM	A	AP	DM	D	DP

1

Figure A1 – Schematic representation of the applied questionnaire.

Universidade Federal de Santa Catarina

Centro Tecnológico
Curso de Pós-grad. em Engenharia de Produção e Sistemas
Programa de Doutorado

Prezado(a) Senhor(a):

Sou professora do Departamento de Informática e de Estatística da UFSC e gostaria de sua colaboração em meu trabalho de pesquisa. Estou realizando meu doutoramento em Engenharia de Produção e Sistemas, na área de Inteligência Aplicada. Estou desenvolvendo uma *simulação computacional* que pretende verificar a relação de alguns *conceitos* entre si, em especial aqueles relacionados com o *processo emocional e motivacional do ser humano*, e sua implicação no **contexto escola/trabalho**. Parte de minha pesquisa se baseia na relação existente entre vários conceitos, e as informações de especialistas (psicólogos experientes) são essenciais para validação do meu trabalho.

Em primeiro lugar definirei o que quero dizer com a palavra *conceito*. *Conceito*, para os fins deste trabalho, significa uma *palavra* ou uma *expressão lingüística* que abstrai e generaliza uma idéia a respeito de uma ou mais representações mentais. Estas representações mentais podem ser outras abstrações (elaborações) lingüísticas; experiências ou generalizações sobre experiências vividas, procedimentos de ação e/ou pensamento; informações analógicas do mundo exterior (visual, auditiva e cinestésicas); etc. O *conceito*, neste sentido é, portanto, um *elemento lingüístico* que agrega um conjunto de informações a nível mental.

O objetivo deste trabalho é verificar a ligação/relação entre alguns *conceitos* em termos de **causa e efeito**. Utilizando-se um conjunto de *conceitos,* se quer verificar o quanto um **causa** (interfere diretamente) um outro. *Causar* é aqui tomado no sentido de *provocar/interferir/aumentar/levar ativação* do outro *conceito*. Também se quer verificar em que *intensidade* esta causação acontece. Para verificar a intensidade da causação você escolherá uma das seguintes gradações: **aumenta muito**, ou **aumenta**, ou **aumenta pouco**, ou **não causa**, ou **diminui pouco**, ou **diminui**, ou **diminui muito**. Você verificará que alguns conceitos possuem relação de **causa e efeito**, porém muitos não possuem relação direta e a resposta sua será **não causa**. Em algumas vezes pode ocorrer que a freqüência que você responde **não causa** é grande. Se isto acontecer, fique tranquilo a respeito de suas respostas. Como se está trabalhando com muitos *conceitos* (48) alguns terão relação direta e outros não.

Assim, considerando um *conceito genérico* ***C1*** e outro *conceito genérico* ***C2***, pergunta-se:

O *conceito **C1*** **causa** o *conceito **C2***?

Possíveis respostas:

1) **Não causa**
2) Sim, causa **aumento**.

   Então, em que intensidade **aumenta**?

   Aumenta muito, **aumenta** ou **aumenta pouco**?
3) Sim, causa **diminuição**

   Então, em que intensidade **diminui**?

   Diminui muito, diminui, ou **diminui pouco**?
4) **Depende da pessoa, do ambiente, de outro conceito, etc**.

   Então neste caso, pode-se dizer que não há uma relação direta de **causa e efeito** entre os *conceitos*, ou apenas uma relação fraca. Neste caso você poderia responder **não causa**, ou **aumenta pouco**, ou **diminui pouco**, de acordo com sua percepção/ experiência, ou o que você acredita que acontece na maior parte dos casos. As relações de dependência deverão aparecer como resultado relações diretas entre os *conceitos*.

Por exemplo, vamos considerar os seguintes 5 *conceitos*: *Sentir fome*, *Buscar comida*, *Comer*, *Estar saciado* e *Ansiedade.*

As perguntas são:

1) O *Sentir fome* **causa** o *Sentir fome* ?

   Resposta possível: sim, **aumenta muito**

2)O *Sentir fome* **causa** o *Buscar comida* ?

   Resposta possível: sim, **aumenta muito**

3) O *Sentir fome* **causa** o *Comer*?

   Resposta possível: sim, **aumenta muito**

4) O *Sentir fome* **causa** o *Estar saciado*?

   Resposta possível: sim, **diminui muito**

5) O *Sentir fome* **causa** *Ansiedade* ?

   Resposta possível: sim, **aumenta pouco**

6) O *Buscar comida* **causa** o *Sentir fome*?

   Resposta provável: **não causa**

   ....

E assim sucessivamente, até que todos os cinco *conceitos* sejam analisados com relacão a si mesmo e a todos os demais. As tabelas na próxima página resumem esta forma de analisar:

A Tabela 1 corresponde a análise feita anteriormente.

A Tabela 2 tem como **causa** o *conceito Buscar comida* e são analisados os **efeitos** sobre os demais *conceitos*, assinalando-se com X o grau de causação correspondente. Na análise desta tabela, considerou-se que o conceito *Buscar comida* **não causa** nenhum dos quatro primeiros, e só **aumenta** *Ansiedade*.

A Tabela 3 analisa-se como **causa** o *conceito Comer*. Neste caso, assinalou-se que este último **diminui muito** o *Sentir fome*, *Buscar comida* e *Comer*; **aumenta muito** o *Estar Saciado*; e **diminui** o *conceito Ansiedade*.

Na Tabela 4 analisa-se como **causa** o *conceito Estar saciado*. Neste caso, assinalou-se que este último **diminui muito** os *conceitos Sentir fome*, *Buscar comida*, *Comer e Ansiedade* ; e **aumenta** o *Estar saciado.*

Já na Tabela 5 analisa-se como **causa** o *conceito Ansiedade*. Aqui assinalou-se que este último **não causa** o *Sentir fome*, *Buscar comida*, *Comer* e *Estar saciado* (afinal, quando ansiosas, algumas pessoas ativam estes conceitos e outras os desativam, dependendo portanto da estratégia pessoal); e **aumenta** a própria *Ansiedade*.

A análise feita acima é uma "possível análise" da relação entre estes 5 *conceitos*. Cada pessoa teria sua própria análise da relação entre eles.

O que se está buscando com esta pesquisa é sua *opinião pessoal* sobre como os 48 conceitos propostos mais adiante, relacionam-se entre si.

Esta análise deverá ser feita tendo em mente o **contexto trabalho/escola**, considerando as relações mais freqüentes ou esperadas para a média das pessoas.

NC = Não Causa
AM = Aumenta Muito
A = Aumenta
AP = Aumenta Pouco
DM = Diminui Muito
D = Diminui
DP = Diminui Pouco

O *SENTIR FOME* CAUSA...

1	...SENTIR FOME?	NC	~~AM~~	A	AP	DM	D	DP
2	...BUSCAR COMIDA?	NC	~~AM~~	A	AP	DM	D	DP
3	...COMER?	NC	~~AM~~	A	AP	DM	D	DP
4	...ESTAR SACIADO?	NC	AM	A	AP	~~DM~~	D	DP
5	...ANSIEDADE?	NC	AM	A	~~AP~~	DM	D	DP

Tabela 1

O *BUSCAR COMIDA* CAUSA...

1	...SENTIR FOME?	~~NC~~	AM	A	AP	DM	D	DP
2	...BUSCAR COMIDA?	~~NC~~	AM	A	AP	DM	D	DP
3	...COMER?	~~NC~~	AM	A	AP	DM	D	DP
4	...ESTAR SACIADO?	~~NC~~	AM	A	AP	DM	D	DP
5	...ANSIEDADE?	NC	AM	~~A~~	AP	DM	D	DP

Tabela 2

O *COMER* CAUSA...

1	...SENTIR FOME?	NC	AM	A	AP	~~DM~~	D	DP
2	...BUSCAR COMIDA?	NC	AM	A	AP	~~DM~~	D	DP
3	...COMER?	NC	AM	A	AP	~~DM~~	D	DP
4	...ESTAR SACIADO?	NC	~~AM~~	A	AP	DM	D	DP
5	...ANSIEDADE?	NC	AM	A	AP	DM	~~D~~	DP

Tabela 3

O *ESTAR SACIADO* CAUSA...

1	...SENTIR FOME?	NC	AM	A	AP	~~DM~~	D	DP
2	...BUSCAR COMIDA?	NC	AM	A	AP	~~DM~~	D	DP
3	...COMER?	NC	AM	A	AP	~~DM~~	D	DP
4	...ESTAR SACIADO?	NC	AM	~~A~~	AP	DM	D	DP
5	...ANSIEDADE?	NC	AM	A	AP	~~DM~~	D	DP

Tabela 4

A *ANSIEDADE* CAUSA...

1	...SENTIR FOME?	~~NC~~	AM	A	AP	DM	D	DP
2	...BUSCAR BUSCAR?	~~NC~~	AM	A	AP	DM	D	DP
3	...COMER?	~~NC~~	AM	A	AP	DM	D	DP
4	...ESTAR SACIADO?	~~NC~~	AM	A	AP	DM	D	DP
5	...ANSIEDADE?	NC	AM	~~A~~	AP	DM	D	DP

Tabela 5

Os conceitos escolhidos relacionam-se com *emoções*, *aspectos motivacionais*, *da personalidade e do "self"*, *objetivos* (meta-objetivos), *expectativa* e *aspectos do ambiente trabalho/escola*. Tais conceitos foram escolhidos baseados principalmente no ponto de vista da *Psicologia Cognitiva* sobre estes aspectos.

O objetivo final do trabalho é estabelecer uma rede de conceitos interligados e analisar o quanto a ativação de um influencia nos demais.

Assim, peço que expresse sua opinião com o preenchimento de um "X" nos espaços correspondentes nos formulários em anexo. Vale lembrar que tais *conceitos* agregam constructos psicológicos *idiossincráticos* e outros que são *socialmente compartilhados* com certos grupos ou pessoas. Portanto, sua marcação (X) expressará apenas sua opinião pessoal com respeito ao relacionamento daqueles *conceitos*.

Agradeço antecipadamente sua colaboração.

Atenciosamente

Profa. Lúcia Helena Martins Pacheco
INE – CTC – UFSC
Campus Universitário – Trindade – Fpolis – SC
Fone: (048) 331 9498
lucia@inf.ufsc.br

Seria interessante dispor de alguns dados seus (opcional):

Nome: ____

Idade:________ anos

Profissão:____

Linha de atuação:____

Se professor, qual o seu departamento , Universidade e titulação:

____

Endereço para contato:

____

Telefone:______________________________

e-mail:______________________________

Se ao final do preenchimento você tiver algo a acrescentar ou contribuir, por favor, utilize este espaço para fazê-lo (o verso da folha também). Seu *feedback* é muito importante!

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Glossário geral de conceitos:

Emoções

1. **Alegria** – contentamento, júbilo, felicidade.
2. **Tristeza** – melancolia, infelicidade.
3. **Medo** – receio, temor ante a noção de perigo real ou imaginário.
4. **Raiva** – sentimento de hostilidade, irritabilidade.
5. **Repulsa** – sentimento ou sensação de aversão, de relutância, de repugnância.
6. **Culpa** – sentimento de responsabilidade por ter transgredimento uma regra moral, por ação ou omissão reprovável ou criminosa.
7. **Inveja** – desejo por obter algo que pertence a outro; desgosto ou pesar pelo bem ou felicidade de outrem.
8. **Ciúme** – sentimento causado pelo receio de perder algo (objeto, pessoa, situação) pelo qual se tem um sentimento exacerbado de posse.
9. **Mágoa** – desgosto, amargura, descontentamento com relação a algo (pessoa, situação).
10. **Vergonha** – sentimento penoso de desonra ou humiliação perante outrem.
11. **Sentimento de empatia -** tendência para sentir o que sentiria caso estivesse na situação e circunstâncias experimentadas por outra pessoa**.**
12. **Frustração** – sentimento causado pela privação de um desejo ou necessidade ou por engano frente a uma expectativa.

Aspectos da Personalidade e Motivacionais

13. **Introversão** – característica da personalidade em que o indivíduo direciona seu interesse mais para suas próprias experiências e sentimentos do que para objetos externos ou outras pessoas.
14. **Extroversão** – característica da personalidade em que o indivíduo direciona seu interesse mais para fora de si mesmo (ambiente, coisas ou pessoas) do que para o seu para seu interior, além de facilmente exteriorizar seus pensamentos e sentimentos.
15. **Desejo de independência** – característica na qual o indivíduo se motiva a controlar os eventos de sua vida evitando a dependência de outras pessoas.
16. **Supervalorização do tempo** – tendência a agir considerando o fator urgência do tempo como de extrema importância.
17. **Desejo de realizar** – desejo de superar obstáculos, atingir objetivos de alto nível.
18. **Desejo de afiliação / associação** – desejo de fazer amizades e conviver com os outros.
19. **Desejo por poder / dominação** – desejo de influenciar,controlar, persuadir, subjugar e comandar os outros.
20. **Desejo de atrair atenção** – desejo chamar atenção sobre si mesmo, exibir-se e impressionar os demais.
21. **Interesse / curiosidade** – motivação que leva a comportamentos exploratórios e/ou investigativos e/ou de manipulação do ambiente e/ou de informações externas ou internas ao indivíduo.
22. **Desejo de vingança** – desejo de punir alguém em reparação a um prejuízo provocado por este alguém.
23. **Motivação** – conjunto de fatores psico-fisiológicos que interagem entre si e direcionam a conduta de um indivíduo.
24. **Lazer** – necessidade de diversão ou *relax*.

Meta-objetivos

25. **Ser recompensado** – propósito de chegar a situações em que a pessoa sinta-se premiada por suas atitudes.
26. **Ser / estar ameaçado** – propósito de afastar-se de situações em que a pessoa sente-se ameaçada.
27. **Ser aceito –** propósito de ser aceito pelos outros.
28. **Ser importante / ter valor** – propósito de chegar a situações em que a pessoa sinta-se que é importante e tem valor para os outros.

Aspectos do *Self*

29. **Autoestima** – sentimento positivo de um indívíduo com relação ao seu valor.
30. **Autoconfiança** – sentimento de segurança com relação a si mesmo.
31. **Arrogância** – excessivo orgulho de si mesmo e de sua importância social.

Meta-ações

32. **Prosseguir / perseverar** – ação de persistir em um comportamento ou intenção apesar das adversidades
33. **Inércia para iniciar / mudar** – dificuldade para começar uma ação ou alterar um comportamento em andamento.
34. **Agir** – praticar ou efetuar algo como agente.
35. **Fugir** – escapar de uma situação, pessoa ou objeto.

Expectativa

36. **Crer na possibilidade de** – acreditar que algo é passível de acontecer.

Aspectos do Ambiente Trabalho/escola

37. **Planejamento e metas** – definição clara de etapas e objetivos a serem atingidos por um projeto.
38. **Organização** – ordem no ambiente físico e social.
39. **Cooperação** – trabalho em conjunto de forma colaborativa.
40. **Satisfação** – contentamento com algo.
41. **Individualismo** – sentimento e conduta egocêntrica.
42. **Confiança no grupo** – sentimento de segurança com relação às atitudes e intenções dos membros de um grupo.
43. **Dedicação** – ato de se empenhar com afinco em determinado serviço ou ocupação.
44. **Sucesso** – resultado positivo de uma ação ou projeto.
45. **Liderança autoritária** – direção impositiva e despótica.
46. **Punição** – penalidade imposta aos indivíduos por desempenho e/ou comportamento inadequado.
47. **Estresse** – excessiva tensão ou solicitação na realização de tarefas.
48. **Competição** – disputa entre indivíduos por vantagem, posição, realização ou obtenção de algo.[12]

Glossário Geral de Conceitos

Conceitos por ordem alfabética

- **Agir** – praticar ou efetuar algo como agente.
- **Alegria** – contentamento, júbilo, felicidade.
- **Arrogância** – excessivo orgulho de si mesmo e de sua importância social.
- **Autoconfiança** – sentimento de segurança com relação a si mesmo.
- **Autoestima** – sentimento positivo de um indivíduo com relação ao seu valor.
- **Ciúme** – sentimento causado pelo receio de perder algo (objeto, pessoa, situação) pelo qual se tem um sentimento exacerbado de posse.
- **Competição** – disputa entre indivíduos por vantagem, posição, realização ou obtenção de algo.
- **Confiança no grupo** – sentimento de segurança com relação às atitudes e intenções dos membros de um grupo.
- **Cooperação** – trabalho em conjunto de forma colaborativa.
- **Crer na possibilidade de** – acreditar que algo é passível de acontecer.
- **Culpa** – sentimento de responsabilidade por ter transgredimento uma regra moral, por ação ou omissão reprovável ou criminosa.
- **Dedicação** – ato de se empenhar com afinco em determinado serviço ou ocupação.
- **Desejo de afiliação / associação** – desejo de fazer amizades e conviver com os outros.
- **Desejo de atrair atenção** – desejo chamar atenção sobre si mesmo, exibir-se e impressionar os demais.
- **Desejo de independência** – característica na qual o indivíduo se motiva a controlar os eventos de sua vida evitando a dependência de outras pessoas.
- **Desejo por poder / dominação** – desejo de influenciar,controlar, persuadir, subjugar e comandar os outros.
- **Desejo de realizar** – desejo de superar obstáculos, atingir objetivos de alto nível.
- **Desejo de vingança** – desejo de punir alguém em reparação a um prejuízo provocado por este alguém.
- **Estresse** – excessiva tensão ou solicitação na realização de tarefas.
- **Extroversão** – característica da personalidade em que o indivíduo direciona seu interesse mais para fora de si mesmo (ambiente, coisas ou pessoas) do que para o seu para seu interior, além de facilmente exteriorizar seus pensamentos e sentimentos.
- **Frustração** – sentimento causado pela privação de um desejo ou necessidade ou por engano frente a uma expectativa.
- **Fugir** – escapar de uma situação, pessoa ou objeto.
- **Individualismo** – sentimento e conduta egocêntrica.
- **Inércia para iniciar / mudar** – dificuldade para começar uma ação ou alterar um comportamento em andamento.

- **Interesse / curiosidade** – motivação que leva a comportamentos exploratórios e/ou investigativos e/ou de manipulação do ambiente e/ou de informações externas ou internas ao indivíduo.
- **Introversão** – característica da personalidade em que o indivíduo direciona seu interesse mais para suas próprias experiências e sentimentos do que para objetos externos ou outras pessoas.
- **Inveja** – desejo por obter algo que pertence a outro; desgosto ou pesar pelo bem ou felicidade de outrem.
- **Lazer** – necessidade de diversão ou *relax*.
- **Liderança autoritária** – direção impositiva e despótica.
- **Mágoa** – desgosto, amargura, descontentamento com relação a algo (pessoa, situação).
- **Medo** – receio, temor ante a noção de perigo real ou imaginário.
- **Motivação** – conjunto de fatores psico-fisiológicos que interagem entre si e direcionam a conduta de um indivíduo.
- **Organização** – ordem no ambiente físico e social.
- **Planejamento e metas** – definição clara de etapas e objetivos a serem atingidos por um projeto.
- **Prosseguir / perseverar** – ação de persistir em um comportamento ou intenção apesar das adversidades
- **Punição** – penalidade imposta aos indivíduos por desempenho e/ou comportamento inadequado.
- **Raiva** – sentimento de hostilidade, irritabilidade.
- **Repulsa** – sentimento ou sensação de aversão, de relutância, de repugnância.
- **Satisfação** – contentamento com algo.
- **Sentimento de empatia -** tendência para sentir o que sentiria caso estivesse na situação e circunstâncias experimentadas por outra pessoa.
- **Ser aceito –** propósito de ser aceito pelos outros.
- **Ser / estar ameaçado** – propósito de afastar-se de situações em que a pessoa sente-se ameaçada.
- **Ser importante / ter valor** – propósito de chegar a situações em que a pessoa sinta-se que é importante e tem valor para os outros.
- **Ser recompensado** – propósito de chegar a situações em que a pessoa sinta-se premiada por suas atitudes.
- **Sucesso** – resultado positivo de uma ação ou projeto.
- **Supervalorização do tempo** – tendência a agir considerando o fator urgência do tempo como de extrema importância.
- **Tristeza** – melancolia, infelicidade.
- **Vergonha** – sentimento penoso de desonra ou humiliação perante outrem.

Appendix B

EXPERTS' RESPONSES

Twelve questionnaires (see Appendix A) were handed over but just nine were returned answered. These questionnaires were tabulated and they are shown in Tables B1, B3, B5, B7, B9, B11, B13, B15, B17. Based on these data collected, some general statistics of the responses were calculated. The frequencies of occurrence of each gradation in each expert's answered questionnaire were computed and the obtained results are shown in Tables B2, B4, B6, B8, B10, B12, B14, B16, and B18 in Appendix B. In these last tables the column on the left side, which is labelled "ACTIVATING", shows a computation of each gradation per line in the matrix of answers. In FCMs the computation per line means the capacity of the concept in the activation or causation of the others. This "causation", in the FCM graph, is represented as an arrow that leaves the node (concept) towards another node. The column on the right side, which is labelled "BEING ACTIVED", shows a computation of each gradation per column in each expert's whole matrix. In FCMs the computation per column means how much a concept receives influence of the others. In the FCM graph, it is represented as arrows getting to a node.

Table B1 – Expert #1's responses.

Expert Number: 1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1	A	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	A	A	MC	MC	A	MC	AM	AM	MC	MC	MC	MC	AM	AM	MC	A	DM	AM	MC	AM	A	MC	MC	AM	MC	MC	A	MC	MC	MC	DM	MC
2	MC	A	A	AP	AM	A	MC	MC	AM	AM	MC	AM	AM	DM	MC	MC	MC	DM	MC	MC	DM	MC	DM	DM	MC	AM	MC	DM	DM	DM	MC	MC	AM	DM	AM	MC	MC	MC	MC	MC	AM	DM	MC	MC	MC	AM	AM	MC
3	MC	AP	AM	A	AM	DP	AM	AM	A	AM	MC	AM	AM	MC	MC	AM	AM	DM	MC	MC	MC	MC	DM	MC	MC	AM	MC	MC	DM	DM	AM	MC	MC	DM	AM	MC	MC	MC	MC	MC	AM	MC	MC	MC	MC	MC	AM	AM
4	MC	A	A	AM	AM	DM	MC	MC	AM	MC	MC	A	DM	AM	AM	MC	A	MC	A	MC	A	AM	AM	MC	MC	MC	MC	AM	AM	AM	AM	AM	MC	AM	DM	AM	A	MC	MC	A	A	DM	DM	MC	AM	AM	AM	AM
5	MC	MC	AM	AM	AM	A	MC	MC	MC	A	MC	MC	AM	MC	AM	MC	MC	MC	A	MC	MC	A	MC	MC	A	AM	MC	MC	MC	MC	AM	A	MC	MC	AM	MC	MC	MC	MC	MC	AM	MC	MC	MC	AM	AM	AM	AM
6	MC	AM	A	MC	A	AM	MC	MC	AM	AM	MC	AM	AM	DM	MC	MC	AM	MC	MC	MC	MC	MC	A	MC	MC	A	MC	MC	MC	MC	MC	MC	MC	DM	AM	A	MC	MC	A	MC	DM	A	A	MC	MC	A	A	MC
7	MC	AM	AM	AM	AM	AM	AM	AM	AM	A	MC	AM	AM	DM	AM	MC	AM	MC	MC	A	MC	AM	AM	MC	MC	AM	MC	AM	DM	DM	AM	A	MC	AM	D	AM	AM	AM	MC	MC	AM	MC	MC	MC	A	A	A	AM
8	MC	AM	AM	AM	AM	A	AM	AM	AM	MC	MC	AM	AM	DM	MC	MC	A	MC	MC	A	A	AM	A	MC	AM	AM	AM	AM	DM	DM	A	MC	MC	MC	MC	AM	MC	MC	MC	MC	AM	MC	AM	MC	A	A	A	AM
9	MC	AM	MC	A	A	A	MC	MC	MC	MC	MC	AM	DM	AM	AM	MC	AM	MC	MC	MC	DM	A	DM	MC	MC	A	MC	DM	DM	DM	MC	MC	A	DM	A	AM	MC	MC	DM	DM	A	MC	MC	MC	MC	MC	A	MC
10	MC	AM	A	A	AM	AM	A	A	AM	AM	MC	AM	AM	DM	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	DM	DM	MC	MC	MC	MC	AM	AM	MC	MC	MC	MC	AM	MC	MC	MC	MC	MC	AM	MC
11	A	DM	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	DM	AM	MC	MC	AM	AM	MC	MC	AM	MC	A	MC	MC	MC	MC	MC	A	A	MC	A	MC	A	MC	AM	A	A	A	AM	DM	AM	AM	MC	MC	MC	MC	MC
12	MC	AM	AM	AM	AM	AP	AP	AP	AM	AM	MC	AM	AM	DM	A	MC	AM	MC	AM	MC	AM	AM	A	MC	AM	AM	A	A	DM	DM	AM	A	MC	A	D	AM	A	A	MC	MC	A	MC	MC	MC	A	A	A	A
13	MC	AM	AM	A	AM	A	MC	MC	AM	AM	MC	AM	AM	DM	AM	MC	MC	MC	MC	MC	A	MC	MC	MC	MC	AM	DM	MC	DM	DM	AM	MC	MC	MC	MC	AM	MC	MC	DM	DM	AM	MC	MC	MC	MC	MC	AM	MC
14	AM	DM	DM	MC	AP	MC	MC	MC	MC	DM	MC	MC	MC	AM	MC	MC	MC	A	MC	AM	A	MC	AM	AM	MC	DM	DM	DM	AM	AM	AM	MC	MC	AM	DM	AM	A	MC	MC	DM	DM	MC	MC	MC	A	MC	MC	A
15	AM	DM	DM	DM	DM	MC	MC	MC	MC	MC	MC	DM	MC	MC	AM	AM	AM	DM	A	DM	AM	MC	AM	AM	DM	DM	DM	DM	AM	AM	A	AM	DM	AM	DM	AM	AM	AM	MC	AM	AM	MC	MC	MC	AM	MC	MC	MC
16	DM	A	AM	AM	AM	MC	MC	MC	A	MC	MC	AM	AM	DM	AM	AM	AM	MC	AM	MC	MC	MC	DM	MC	AM	AM	AM	AM	DM	DM	AM	DM	AM	AM	D	AM	AM	AM	AM	MC	A	MC	AM	MC	MC	AM	AM	MC
17	A	D	A	D	D	MC	MC	MC	MC	MC	MC	DM	D	A	A	A	AM	MC	A	MC	AM	MC	AM	D	A	AM	DM	A	AM	AM	A	AM	A	AM	DM	AM	AM	MC	AM	MC	MC	MC	AM	MC	MC	MC	MC	MC
18	AM	DM	D	MC	MC	MC	MC	MC	MC	MC	AM	AM	DM	AM	MC	MC	AM	AM	MC	AM	AM	MC	AM	AM	AM	MC	AM	AM	MC	MC	MC	MC	A	MC	MC	MC	AM	AM	AM	MC	MC	MC	AM	MC	MC	MC	MC	MC
19	A	DM	DM	DM	AM	DM	AM	DM	AM	DM	DM	DM	MC	MC	AM	MC	AM	A	AM	AM	AM	AM	AM	MC	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	DM	AM	DM	MC	DM	DM	AM	DM	DM	DM	AM	A	AM	AM
20	A	A	A	A	A	A	A	A	A	A	MC	AM	DM	AM	MC	MC	A	AM	AM	AM	AM	DP	A	A	AM	A	AM	AM	MC	MC	A	A	AM	AM	DM	AM	MC	MC	MC	MC	A	MC	MC	MC	A	MC	A	AM
21	A	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	A	DM	AM	A	A	AM	DM	MC	MC	AM	MC	AM	A	MC	DM	DM	MC	AM	AM	AM	AM	DM	AM	DM	AM	AM	MC	AM	MC	A	MC	AM	AM	A	MC	MC	MC
22	DM	A	DM	AM	AM	DM	MC	MC	AM	DM	MC	A	AM	DM	AM	MC	A	DM	AM	MC	AM	AM	AM	MC	MC	DM	MC	MC	A	A	A	AM	DM	A	D	AM	AM	A	MC	AM	AP	MC	AM	MC	AP	AM	MC	AM
23	AM	MC	DM	MC	MC	MC	MC	MC	MC	DM	MC	AP	DM	AM	AP	A	AM	MC	A	MC	AM	AM	AM	AM	A	DM	DM	DM	AM	AM	A	AM	DM	AM	DM	AM	AM	MC	A	A	A	A	AM	AM	AP	MC	MC	AP
24	AM	DM	MC	MC	MC	DM	MC	MC	MC	DM	MC	DM	DM	AM	AP	MC	AP	AM	MC	MC	AP	MC	AM	AM	MC	DM	MC	MC	A	A	MC	AP	MC	AM	DM	MC	DM	DM	DM	AM	MC	MC	DM	DM	MC	MC	MC	MC
25	AM	DM	DM	DM	MC	MC	MC	MC	MC	A	MC	MC	MC	MC	AP	AM	AM	A	A	AM	AM	MC	AM	MC	AM	AM	AM	AM	AM	AM	AM	AM	DM	AM	DM	AM	AM	MC	AM	AM	DM	MC	AM	AM	AM	MC	MC	A
26	A	D	DM	DM	DM	MC	MC	MC	A	MC	MC	AM	MC	MC	AP	MC	MC	DM	AM	MC	A	AM	AM	MC	DM	AM	DM	DM	D	D	A	MC	AM	DM	AM	AM	DM	MC	DM	DM	AM	DM	DM	DM	A	MC	AM	AM
27	D	A	A	A	A	MC	AM	AM	AM	MC	MC	AM	MC	MC	DM	MC	MC	AM	MC	AM	AM	MC	AM	MC	AM	AM	AM	AM	DM	DM	DM	A	AP	DM	AM	AM	MC	MC	AM	MC	MC	MC	AM	DM	MC	AM	AM	MC
28	A	A	A	A	A	A	A	A	A	A	MC	AM	DM	AM	MC	A	A	A	MC	AM	MC	AP	AM	MC	AM	AM	AM	AM	DM	DM	A	A	MC	MC	MC	AM	AM	MC	AM	DM	A	MC	A	DM	AP	MC	AM	AM
29	AM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	AM	A	MC	AM	A	AP	MC	AM	MC	AM	A	DM	DM	DM	DM	AM	AM	DM	AM	MC	A	DM	AM	D	MC	D	MC	A	DP	A	A	MC	MC	MC	MC
30	AM	DM	DM	MC	A	MC	MC	MC	MC	DM	MC	DM	DM	AM	AM	MC	AM	MC	MC	MC	A	MC	AM	MC	DM	DM	DM	DM	A	A	A	AM	DM	AM	DM	AM	A	MC	DM	A	A	DP	DP	AM	AP	MC	DM	MC
31	MC	A	A	A	AM	MC	AP	AP	MC	DM	MC	AP	DM	AM	AM	MC	AP	DM	AM	AM	DP	AP	A	MC	AM	DM	DM	DM	AP	AM	AM	AM	AM	A	D	AM	DM	DM	DM	DM	AM	DM	DM	DP	A	A	AP	AM
32	A	DP	AP	MC	MC	MC	MC	MC	MC	MC	MC	DM	MC	MC	MC	A	AM	MC	A	MC	A	MC	AM	MC	AM	DM	DM	MC	AM	AM	MC	AM	DM	AM	DM	MC	AM	MC	AM	AM	MC	AM	AM	AM	MC	AM	AM	MC
33	MC	AM	DM	A	AM	AM	A	A	AM	AM	DM	A	MC	MC	MC	MC	DM	MC	MC	MC	DM	MC	DM	MC	DM	AM	MC	MC	D	D	AP	DM	AM	DM	AM	DM	DM	MC	DM	D	AP	MC	MC	MC	MC	MC	MC	MC
34	A	MC	D	MC	MC	DM	MC	MC	MC	DM	MC	AP	D	A	A	AM	AM	MC	AP	MC	AM	MC	A	MC	AM	DM	DM	MC	AM	AM	AP	AM	DM	AM	DM	AM	MC	MC	MC	AM	AM	DM	MC	MC	AM	AM	AM	AM
35	AM	AM	AM	AM	AM	AM	AM	AM	AM	DM	DM	AM	MC	MC	MC	MC	MC	MC	MC	MC	DM	AM	AM	MC	MC	AM	MC	MC	DM	DM	AP	DM	AM	AM	AM	AM	MC	MC	MC	DM	AM	MC	MC	MC	AP	MC	AM	AM
36	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	MC	AM	MC	MC	AM	MC	AM	DM	AM	AM	AM	MC	MC	MC	MC	MC	MC	DM	AP	AP	AM	AM	DM	AM	AM	AM	MC	MC	AM	MC	MC	MC	AM	A	AP	MC	AM	MC
37	AP	MC	DP	MC	MC	MC	MC	MC	MC	MC	DM	DP	MC	MC	MC	A	A	MC	MC	MC	AM	MC	AM	DP	MC	MC	MC	MC	A	A	MC	AM	DM	AM	DM	A	AM	MC	AM	MC	MC	AP	MC	AM	MC	A	A	MC
38	AP	MC	MC	DM	DM	MC	MC	MC	MC	DM	MC	MC	MC	MC	AM	AM	MC	MC	AP	MC	MC	MC	AP	DM	MC	MC	MC	MC	AP	MC	MC	AP	MC	MC	MC	MC	AM	AM	MC	AP	MC	MC	MC	MC	MC	MC	A	MC
39	A	D	D	D	MC	MC	D	D	D	MC	A	D	D	A	DM	A	A	AM	MC	MC	AM	MC	AM	MC	A	DM	MC	A	MC	MC	MC	A	DM	A	D	MC	A	MC	AM	A	DM	AM	A	A	DM	DM	DM	DM
40	AM	DM	MC	MC	MC	MC	MC	MC	MC	MC	AM	DM	DM	AM	A	MC	A	MC	MC	MC	AM	MC	AM	MC	DM	MC	DM	A	A	A	MC	A	MC	A	MC	A	DM	MC	D	AP	AP	MC	DM	DP	MC	DM	DM	MC
41	MC	MC	AM	AM	AM	DM	MC	MC	MC	DM	DM	DM	AM	DM	AM	MC	A	MC	MC	MC	A	MC	A	DM	DM	DM	DM	DM	A	A	A	A	MC	MC	MC	AM	DM	MC	DM	MC	AM	DM	DM	DM	A	MC	A	AM
42	A	DM	DM	DM	DM	MC	DM	DM	DM	DM	AM	DM	DM	AM	D	MC	A	AM	DM	MC	A	MC	A	AP	A	A	A	A	MC	MC	MC	A	DM	A	D	AM	A	MC	AM	AM	DM	AM	AM	A	MC	AM	MC	MC
43	AP	MC	DM	DM	MC	MC	MC	MC	MC	MC	MC	DM	MC	MC	AM	AM	AM	AP	AP	MC	AM	MC	AM	DM	AP	DP	AP	AP	MC	MC	MC	AM	DM	AM	DM	AM	AM	MC	AM	AM	MC	MC	AM	AM	MC	MC	AM	AP
44	AM	DM	DM	DM	MC	MC	MC	MC	MC	MC	AP	DM	MC	MC	AP	MC	DP	DP	A	A	DP	MC	DP	AM	MC	MC	MC	AM	A	A	A	DP	AP	DP	MC	MC	DM	MC	D	AM	MC	MC	DP	MC	MC	AM	A	A
45	A	D	A	A	A	A	A	A	A	DM	DM	DP	MC	MC	MC	AM	A	DM	AM	A	A	AM	A	MC	MC	DM	DM	A	A	A	A	A	AM	A	A	AM	DM	MC	DM	DM	AM	DM	DM	DM	A	A	A	A
46	AP	AP	DM	MC	AM	AP	MC	MC	MC	AP	MC	AM	AM	DM	MC	MC	AM	DM	MC	DM	MC	AM	A	MC	AM	AM	MC	MC	DM	DM	DM	DM	MC	MC	AM	AM	DM	MC	DM	DM	A	D	DM	D	A	AM	AM	MC
47	DM	AM	AM	AM	AM	AM	MC	MC	MC	MC	MC	AP	MC	MC	AM	AM	AM	DM	A	A	DM	MC	DM	MC	AM	AM	AM	MC	MC	MC	MC	DM	AM	DM	AM	AM	MC	MC	MC	MC	AM	MC	MC	MC	MC	AM	AM	MC
48	DM	AM	AM	AM	AM	DM	AM	AM	AM	MC	MC	A	DM	AM	AM	AM	AM	DM	A	MC	A	AM	A	MC	A	DM	MC	AM	A	A	A	A	DM	A	D	AM	DM	MC	DM	DM	AM	DM	DM	DM	A	AM	AM	AM

Table B2 – Frequency of occurrence of expert#1's responses.

Expert Number: 1

Occurrence of Answers Concerning Activation Characteristics:

Concept	A C T I V A T I N G							Concept	B E I N G A C T I V A T E D						
	NC	AM	A	AP	DM	D	DP		NC	AM	A	AP	DM	D	DP
1	31	8	7	0	2	0	0	1	14	12	13	4	4	1	0
2	23	11	3	1	10	0	0	2	9	12	8	2	12	4	1
3	24	15	2	1	5	0	1	3	7	12	10	1	14	3	1
4	16	18	9	0	5	0	0	4	14	12	10	1	9	2	0
5	29	13	6	0	0	0	0	5	14	20	7	1	5	1	0
6	27	8	10	0	3	0	0	6	22	7	8	2	8	0	1
7	15	23	6	0	3	1	0	7	30	8	5	2	2	1	0
8	18	18	9	0	3	0	0	8	30	7	5	2	3	1	0
9	24	6	9	0	9	0	0	9	24	15	6	0	2	1	0
10	29	12	4	0	3	0	0	10	20	8	5	1	14	0	0
11	27	9	9	0	3	0	0	11	34	4	2	1	7	0	0
12	12	16	13	3	3	1	0	12	6	18	5	4	12	1	2
13	26	13	3	0	6	0	0	13	17	13	0	0	15	3	0
14	23	10	5	1	9	0	0	14	17	17	3	0	11	0	0
15	16	17	2	0	13	0	0	15	17	17	6	5	2	1	0
16	15	23	3	0	6	1	0	16	31	10	7	0	0	0	0
17	18	12	10	0	3	5	0	17	9	23	12	2	1	0	1
18	27	17	1	0	2	1	0	18	21	7	6	1	12	0	1
19	5	25	3	0	15	0	0	19	24	9	10	4	1	0	0
20	13	13	19	0	2	0	1	20	32	9	5	0	2	0	0
21	20	14	8	0	6	0	0	21	9	19	12	1	5	0	2
22	13	16	8	2	8	1	0	22	31	12	2	2	0	0	1
23	13	15	8	4	8	0	0	23	4	24	12	1	6	0	1
24	23	7	2	4	12	0	0	24	31	7	3	1	4	1	1
25	15	22	4	1	6	0	0	25	20	14	6	1	7	0	0
26	14	11	5	1	14	3	0	26	9	19	4	0	15	0	1
27	17	18	5	1	6	1	0	27	21	9	2	1	15	0	0
28	11	13	17	2	5	0	0	28	18	12	6	1	11	0	0
29	10	9	7	1	18	2	1	29	8	12	10	3	13	2	0
30	15	9	8	1	13	0	2	30	9	13	10	1	13	2	0
31	6	13	7	7	12	1	2	31	16	13	13	3	3	0	0
32	22	15	4	1	5	0	1	32	10	16	14	2	5	0	1
33	20	8	4	2	11	3	0	33	18	10	3	2	15	0	0
34	17	15	4	3	7	2	0	34	9	20	10	0	8	0	1
35	19	20	0	2	7	0	0	35	10	12	2	0	16	8	0
36	17	24	1	3	3	0	0	36	9	35	3	0	1	0	0
37	26	7	7	2	3	0	3	37	14	14	8	0	11	1	0
38	33	4	1	6	4	0	0	38	38	5	3	0	2	0	0
39	13	5	13	0	8	9	0	39	17	13	3	0	12	3	0
40	22	5	8	2	9	1	1	40	19	11	4	2	11	1	0
41	16	8	9	0	15	0	0	41	11	17	11	3	6	0	0
42	11	9	12	1	13	2	0	42	29	4	2	1	9	1	2
43	20	14	0	7	6	0	1	43	17	14	5	0	10	0	2
44	20	5	7	3	5	1	7	44	26	7	4	0	8	1	2
45	6	6	23	0	11	1	1	45	23	6	12	6	1	0	0
46	16	11	3	4	12	2	0	46	25	13	8	0	2	0	0
47	22	17	2	1	6	0	0	47	13	19	11	1	4	0	0
48	6	18	11	0	12	1	0	48	25	15	5	2	1	0	0
Sum:	881	625	321	67	350	39	21	Sum:	881	625	321	67	350	39	21
% :	38.2	27.1	13.9	2.9	15.2	1.7	.9	% :	38.2	27.1	13.9	2.9	15.2	1.7	.9

Table B3 – Expert #2's responses.

Expert Number: 2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1	AM	DM	MC	DM	MC	DM	MC	MC	MC	DM	A	MC	D	A	AP	DM	A	DM	MC	MC	AP	MC	AM	AM	MC	MC	D	AP	A	A	D	AM	D	A	MC	A	A	AP	AP	AM	MC	AP	A	AP	D	DM	DM	D
2	DM	AM	A	AP	MC	AP	AP	AP	AM	AP	DM	AM	A	AP	MC	AP	DM	A	MC	AP	MC	AP	DM	DM	AM	A	A	A	DM	D	MC	DM	A	D	A	D	D	DP	DP	DM	AP	D	DP	D	MC	AP	AM	MC
3	DM	A	AM	AP	MC	A	MC	MC	AM	A	DP	AM	A	D	AM	MC	D	AP	D	MC	MC	AP	DM	DM	AM	AM	A	A	D	DM	MC	DM	A	D	AM	D	D	DP	D	DM	AP	D	D	D	AP	AP	AM	D
4	MC	AP	AP	AM	A	AP	A	A	AM	DP	DM	AM	MC	MC	AP	A	A	A	AM	AP	MC	AM	AP	DP	AM	A	A	A	D	D	AM	A	DP	A	AP	DP	AP	MC	MC	D	A	D	MC	D	AM	A	AM	A
5	DM	A	AP	AP	AM	AP	MC	MC	MC	AP	DM	A	AM	DM	MC	MC	DP	AP	MC	MC	DM	DM	DM	D	MC	AP	AP	AP	MC	MC	MC	D	AP	AP	AM	D	MC	MC	DM	D	A	D	MC	D	AP	MC	A	MC
6	DM	AP	AP	AP	AP	AM	AP	AP	A	AM	A	AM	A	D	AP	MC	DP	A	MC	MC	DM	MC	D	D	A	AM	A	A	DM	DM	AP	D	AP	DP	AM	DP	MC	MC	A	DM	AP	D	D	D	MC	AM	AM	DM
7	DM	A	AP	AM	MC	D	AM	AM	A	AP	DM	AM	AP	DP	MC	MC	AP	AP	A	A	AP	AP	AP	DP	A	AP	A	A	D	D	A	AP	DP	AP	AP	D	AP	MC	DP	DM	A	D	D	MC	AP	AP	AM	A
8	D	A	AM	A	MC	AP	AP	AM	AM	AP	D	AM	AP	D	MC	AP	MC	MC	AM	AM	AM	AP	A	D	AP	AM	A	A	DM	DM	AP	DP	MC	A	MC	A	AP	MC	DP	DM	AM	D	DP	MC	A	AP	AM	A
9	DM	A	AP	A	AP	MC	AP	A	AM	AP	D	A	A	DM	AP	MC	D	A	MC	MC	DP	AP	D	DP	AP	AP	A	A	D	D	MC	D	A	D	AP	DP	DP	DP	D	DM	AP	D	D	MC	MC	MC	A	AP
10	D	A	AP	AP	AP	AP	MC	MC	AP	AM	D	A	AP	DP	MC	MC	MC	AP	MC	DM	MC	AP	D	DP	MC	AP	MC	D	D	D	MC	DP	AP	DP	AP	MC	MC	MC	DP	D	MC	DP	MC	MC	MC	AP	AP	MC
11	AP	DP	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	D	A	MC	MC	AP	AP	MC	MC	AP	MC	A	A	MC	MC	A	AM	AM	AM	MC	AP	DP	AP	MC	AP	AP	A	AM	AM	DM	A	A	A	DM	D	DM	DM
12	DM	AM	AP	AP	MC	AP	AP	AP	A	AP	D	AM	AP	DP	AP	MC	MC	AP	AP	AP	MC	AP	DP	DP	AP	AP	A	AP	D	D	MC	DP	AP	DP	AP	DP	D	DP	D	DM	A	D	D	D	MC	MC	A	AP
13	MC	MC	MC	MC	MC	MC	AP	MC	MC	AP	D	AP	AM	DM	MC	MC	MC	DM	DM	DM	DP	MC	D	DP	MC	MC	DP	DP	DP	DM	MC	MC	MC	AP	DP	MC	MC	D	D	AP	DP	MC	MC	MC	MC	AP	D
14	AP	DP	MC	MC	MC	MC	MC	MC	MC	MC	A	DP	DM	AM	MC	MC	A	AP	MC	AP	AP	MC	AP	AM	MC	MC	AP	AP	A	A	MC	MC	MC	MC	MC	MC	MC	MC	AP	A	DM	A	AP	A	MC	MC	D	MC
15	MC	MC	AP	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	AP	DM	MC	MC	AP	MC	AP	AP	MC	MC	AP	AP	A	A	MC	AP	MC	AP	MC	AP	A	A	DP	AP	AM	AP	AP	AP	AP	MC	AP	AP
16	DP	AP	AP	AP	MC	AP	MC	MC	MC	MC	DP	A	AP	DP	MC	AM	AM	MC	A	MC	AP	MC	AP	DP	MC	A	MC	MC	DP	DP	MC	AP	DM	AM	MC	MC	AM	AM	A	AP	AP	DP	D	MC	A	MC	AM	AP
17	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	AP	AM	AM	AP	A	MC	AP	MC	AM	D	A	MC	AP	AP	A	A	MC	AM	DM	AM	MC	A	AM	AM	AM	AP	D	A	AM	A	AM	MC	AM	A
18	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	AP	DP	MC	AP	AM	AP	MC	AP	MC	A	AP	AP	MC	AM	AM	A	A	MC	AP	DP	A	DP	A	A	A	A	AM	DM	AM	AM	AP	DM	DM	A	D
19	MC	MC	MC	MC	MC	MC	AP	AP	MC	MC	D	MC	MC	MC	AM	A	A	MC	AM	AP	AP	MC	AM	DP	AM	AP	AP	A	A	A	AP	AM	DM	AM	MC	A	AM	A	D	MC	A	D	D	AP	AM	AP	AM	AM
20	DP	AP	AP	AP	MC	MC	AP	AP	AP	MC	DP	AP	DP	AP	MC	AP	AP	AM	MC	AM	AP	MC	A	AP	AP	AP	AM	AM	AP	AP	MC	AP	DP	AP	MC	AP	AP	AP	A	DP	A	AP	A	MC	D	AP	A	D
21	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	DP	AP	MC	MC	AP	AP	MC	MC	AM	MC	AP	AP	MC	MC	AP	MC	AP	AP	MC	A	D	A	MC	A	A	A	A	AP	D	A	A	A	DM	MC	MC	D
22	MC	MC	MC	A	AP	D	AP	AP	AM	DP	DM	AP	MC	MC	MC	MC	A	MC	AP	A	AP	AM	A	D	A	DP	MC	A	DP	DP	A	AP	D	A	MC	AP	A	AP	D	D	AM	D	DP	MC	MC	MC	AM	A
23	AP	D	D	MC	MC	MC	MC	MC	MC	MC	AP	D	MC	MC	AP	AP	AM	MC	MC	DM	AM	MC	AM	AP	AM	MC	AP	AM	AM	AM	MC	AM	DM	AM	MC	A	AM	A	A	AP	MC	AP	AM	A	MC	MC	MC	MC
24	A	D	DP	MC	MC	MC	MC	MC	MC	MC	AP	DP	DP	AP	MC	MC	MC	AP	MC	MC	AP	MC	AP	AM	AP	MC	AP	AP	A	A	MC	MC	DP	AP	MC	MC	AP	AP	MC	A	MC	AP	MC	MC	MC	MC	DM	MC
25	AM	DM	MC	MC	MC	MC	MC	MC	MC	MC	AP	DM	MC	MC	MC	MC	AM	MC	MC	MC	AP	MC	AM	A	AM	MC	A	AM	AM	AM	MC	A	DM	A	MC	A	A	AP	A	AM	DP	A	A	A	MC	MC	D	MC
26	DM	A	AM	AP	AP	MC	MC	MC	AP	AP	DM	A	A	D	MC	AP	DM	A	AP	DM	D	AP	DM	DM	MC	AM	MC	MC	DM	DM	DM	D	D	A	AM	DP	AP	MC	MC	MC	AP	DP	MC	MC	MC	MC	AM	MC
27	AM	DM	DM	DM	MC	DM	MC	MC	DM	MC	AM	DM	MC	MC	MC	MC	AP	AM	DM	A	AP	MC	AM	AM	AM	MC	AM	AM	AM	AM	MC	A	D	A	MC	A	AP	AP	A	AM	D	A	A	A	MC	MC	DM	MC
28	AM	DM	MC	DM	MC	MC	MC	MC	DM	MC	AM	DM	MC	MC	MC	MC	A	AM	MC	MC	MC	MC	AM	A	A	MC	AM	AM	AM	AM	MC	A	D	AM	MC	A	AP	AP	A	A	DM	AM	AM	AP	DM	MC	DM	MC
29	AP	DP	MC	MC	MC	MC	DM	DM	MC	MC	A	MC	MC	MC	A	MC	A	A	MC	MC	A	MC	A	AM	MC	MC	MC	AM	AM	AM	MC	A	D	A	MC	A	A	A	A	AM	DM	A	A	A	MC	MC	DM	MC
30	AP	DM	DM	DM	MC	MC	MC	DM	DM	MC	AM	MC	DP	A	AM	MC	AM	A	MC	MC	A	MC	AM	AM	MC	MC	MC	AM	AM	AM	MC	A	D	A	MC	A	AP	A	AM	AM	DM	A	A	AP	MC	MC	DM	MC
31	MC	MC	MC	AP	MC	MC	MC	MC	MC	MC	DM	AP	MC	MC	AM	MC	AP	MC	AM	A	MC	AP	AP	MC	AM	AP	A	AM	MC	MC	AM	MC	MC	MC	MC	AP	MC	MC	DM	MC	AM	DM	DM	MC	A	MC	MC	AM
32	AP	DP	D	MC	MC	MC	MC	MC	MC	MC	MC	DP	MC	MC	AP	MC	AM	AP	MC	MC	A	MC	AM	MC	A	MC	A	A	A	A	MC	AM	DM	A	MC	A	AM	AM	AM	AP	DM	A	A	A	MC	MC	AP	DM
33	DM	AM	A	AP	MC	A	AP	AP	A	AP	D	A	MC	MC	MC	MC	D	AP	DM	MC	DM	MC	DM	DM	DM	A	DM	DM	DM	DM	MC	DM	AM	DM	A	MC	DM	DM	DM	DM	A	DM	DM	MC	MC	A	AM	MC
34	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	AP	DP	MC	MC	AP	A	AM	AP	AP	AP	A	MC	A	A	AP	MC	AP	A	A	A	MC	AM	DM	AM	MC	A	A	A	AM	AP	D	A	A	AP	MC	MC	AP	AP
35	MC	MC	AP	AP	MC	MC	MC	MC	MC	AP	MC	AP	MC	MC	MC	AP	DM	DM	DM	MC	MC	MC	MC	DM	MC	AM	A	A	DM	DM	MC	DM	MC	A	AM	DM	D	D	DM	DM	A	D	D	D	MC	MC	AM	MC
36	AP	DP	DP	DP	MC	MC	MC	MC	D	MC	MC	D	MC	MC	AP	MC	AP	MC	MC	MC	A	MC	AP	AP	MC	MC	MC	MC	AP	AP	MC	AP	D	A	MC	AM	A	A	A	AP	MC	AP	A	AP	MC	MC	DP	MC
37	AP	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	DP	MC	MC	MC	AP	AM	MC	MC	MC	AP	MC	A	AP	AP	MC	MC	MC	AP	A	MC	A	DM	AM	MC	AP	AM	A	A	A	DM	A	A	AP	MC	MC	AP	MC
38	AP	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	DM	MC	MC	MC	MC	A	MC	MC	MC	AP	MC	A	A	A	MC	AP	AP	A	A	MC	A	DM	A	MC	A	AM	AM	AP	A	MC	AP	AP	A	MC	MC	DP	MC
39	AP	DP	MC	MC	MC	MC	MC	MC	MC	MC	AM	DP	MC	MC	MC	MC	A	A	DM	MC	AP	MC	A	A	AP	MC	A	A	A	A	MC	A	DM	A	MC	AP	A	A	AM	A	DM	AM	A	A	DM	MC	MC	MC
40	AM	DM	MC	MC	MC	MC	MC	MC	MC	MC	A	DM	MC	MC	MC	MC	A	MC	MC	MC	AP	MC	AM	A	DM	MC	MC	AM	AM	AM	MC	A	DM	A	MC	A	A	A	A	AM	DM	AM	A	AP	MC	MC	DM	MC
41	MC	MC	MC	MC	MC	MC	AP	AP	MC	MC	DM	MC	MC	MC	AM	MC	AP	DM	A	AP	AP	MC	AP	MC	A	AP	A	A	MC	MC	AP	AP	MC	MC	MC	MC	AP	AP	DM	MC	AM	DM	DM	MC	AM	AP	MC	AM
42	MC	MC	DM	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	MC	MC	MC	AP	AM	DM	MC	AP	MC	A	A	MC	DM	AP	AP	A	A	MC	AP	DM	AP	MC	AP	AP	AP	AM	A	DM	AM	A	MC	DM	MC	DM	MC
43	AP	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	D	MC	MC	MC	MC	AM	AM	DM	AP	AP	MC	AM	A	AP	MC	AP	AP	A	A	DM	A	MC	A	MC	A	A	A	AM	A	MC	AM	AM	AP	MC	MC	D	MC
44	AM	DM	MC	MC	MC	MC	MC	MC	MC	MC	AP	DM	MC	MC	MC	MC	AM	AP	MC	AP	A	MC	AM	AM	AP	DM	AP	AP	AM	AM	AP	AM	DM	A	MC	AM	A	A	AP	AM	MC	AP	AP	AM	MC	MC	MC	AP
45	MC	MC	AP	AP	MC	MC	MC	MC	MC	MC	DM	MC	MC	MC	AM	AP	AM	DM	AM	AP	AP	MC	MC	MC	MC	AP	DM	A	AP	A	AM	AP	D	AP	MC	AP	A	A	DM	AP	AM	DM	DM	MC	AM	AP	A	AM
46	DM	AM	A	A	AP	AM	AP	AP	AM	AP	DM	AM	A	D	AM	AP	D	MC	A	MC	MC	A	DM	DM	A	AM	A	A	DM	DM	MC	D	MC	DP	AM	D	MC	MC	DM	DM	AP	DM	DM	MC	MC	AM	AM	A
47	DM	A	AP	MC	MC	MC	MC	MC	MC	MC	D	AP	MC	MC	MC	AM	D	MC	MC	MC	D	MC	DM	DM	MC	AP	MC	MC	DP	DP	MC	D	A	D	AP	D	D	D	D	DM	AP	D	D	D	MC	AP	AM	MC
48	MC	MC	AP	AP	MC	MC	MC	AP	MC	MC	DM	AP	MC	MC	AM	A	AM	D	A	AP	A	MC	A	D	AM	A	AP	A	AP	AP	A	AM	DM	AM	MC	A	AP	AP	DM	MC	AM	DM	DM	DP	AM	A	AM	AM

Table B4 – Frequency of occurrence of expert #2's responses.

Expert Number: 2

Occurrence of Answers Concerning Activation Characteristics:

Concept	A C T I V A T I N G							Concept	B E I N G A C T I V A T E D						
	NC	AM	A	AP	DM	D	DP		NC	AM	A	AP	DM	D	DP
1	13	5	9	7	8	6	0	1	15	6	1	11	11	2	2
2	7	5	8	11	8	6	3	2	17	4	8	4	7	2	6
3	7	8	7	6	6	12	2	3	21	3	3	14	3	2	2
4	7	9	14	8	1	5	4	4	23	2	4	14	4	0	1
5	16	3	4	11	7	6	1	5	40	1	1	6	0	0	0
6	7	7	8	10	6	7	3	6	33	2	2	7	2	2	0
7	5	5	10	15	3	6	4	7	33	1	1	12	1	0	0
8	8	10	9	10	3	5	3	8	32	2	2	10	2	0	0
9	8	1	10	11	3	10	5	9	30	7	4	3	3	1	0
10	18	1	2	13	1	7	6	10	31	2	1	11	1	0	2
11	18	6	8	8	4	2	2	11	7	7	7	5	11	8	3
12	7	2	4	18	2	8	7	12	12	8	6	7	6	3	6
13	24	1	0	6	5	5	7	13	28	2	6	5	1	2	4
14	25	2	7	9	2	1	2	14	27	1	3	5	3	5	4
15	23	2	4	17	1	0	1	15	27	9	1	10	0	0	1
16	17	6	5	11	1	1	7	16	31	3	4	9	1	0	0
17	20	11	8	6	1	2	0	17	5	12	10	11	3	5	2
18	17	6	10	8	3	1	3	18	13	6	8	14	6	1	0
19	15	10	8	9	1	4	1	19	24	5	6	5	7	1	0
20	9	4	5	23	0	2	5	20	27	2	4	11	4	0	0
21	23	1	10	9	1	3	1	21	9	3	7	22	3	2	2
22	13	4	10	9	1	6	5	22	35	2	1	9	1	0	0
23	20	11	4	8	2	3	0	23	2	12	12	10	7	4	1
24	25	1	4	12	1	1	4	24	4	7	9	7	7	6	8
25	22	8	10	3	3	1	1	25	17	9	9	11	2	0	0
26	15	4	5	9	9	4	2	26	23	6	5	11	2	0	1
27	15	11	8	4	8	2	0	27	11	4	16	14	2	1	0
28	19	11	7	3	7	1	0	28	6	11	17	11	1	1	1
29	21	5	15	1	4	1	1	29	3	9	13	6	7	6	4
30	17	10	9	3	7	1	1	30	3	9	15	4	7	6	4
31	27	7	3	7	4	0	0	31	33	3	3	5	3	1	0
32	20	6	11	5	3	1	2	32	4	8	12	11	4	6	3
33	12	3	8	5	18	2	0	33	9	1	4	4	14	10	6
34	18	4	12	11	1	1	1	34	4	8	19	8	1	4	4
35	21	3	4	5	10	5	0	35	32	6	2	7	0	0	1
36	23	1	6	11	0	3	4	36	6	2	18	9	1	6	6
37	25	3	8	9	2	0	1	37	7	7	14	13	1	5	1
38	25	2	11	7	2	0	1	38	11	4	16	10	1	2	4
39	20	3	15	4	4	0	2	39	3	8	13	4	8	7	5
40	23	7	10	2	6	0	0	40	5	9	8	9	11	5	1
41	23	4	4	12	5	0	0	41	8	7	8	9	11	4	1
42	22	4	6	9	7	0	0	42	0	6	11	8	6	13	4
43	21	7	9	7	2	2	0	43	6	5	15	4	6	9	3
44	19	10	4	11	4	0	0	44	16	1	11	11	0	8	1
45	17	7	5	12	6	1	0	45	27	6	3	4	6	2	0
46	9	9	9	6	10	4	1	46	30	2	3	10	2	1	0
47	20	2	2	6	4	12	2	47	6	16	6	6	9	3	2
48	12	9	9	10	5	2	1	48	22	5	6	6	3	6	0
Sum:	818	261	358	417	202	152	96	Sum:	818	261	358	417	202	152	96
% :	35.5	11.3	15.5	18.1	8.8	6.6	4.2	% :	35.5	11.3	15.5	18.1	8.8	6.6	4.2

Table B5 – Expert #3's responses.

Expert Number: 3

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1	A	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	A	A	A	AM	AP	MC	A	A	MC	AM	AM	AP	MC	AM	A	A	AM	MC	A	D	AM	MC	A	A	A	AM	AM	MC	A	AM	A	D	MC	MC	A
2	MC	A	A	AP	A	MC	MC	MC	A	AP	MC	A	A	MC	DM	D	DM	D	DM	A	DM	A	DM	D	A	A	A	A	D	D	D	DM	AM	D	A	DM	DM	D	D	DM	AM	D	D	DM	AP	A	AM	D
3	MC	A	AM	A	A	A	MC	A	MC	A	DM	A	AM	MC	DM	D	DM	AM	DM	DM	DM	DM	DM	DM	A	AM	A	A	D	DM	D	DM	AM	DM	AM	DM	DM	D	DM	DM	A	A	D	DM	D	MC	AM	DM
4	MC	A	MC	A	AM	A	MC	MC	A	AP	MC	A	A	D	A	A	A	MC	A	MC	DM	AM	DM	D	D	A	DM	D	D	D	A	D	A	D	A	D	D	D	D	D	A	DM	DM	DM	AM	A	A	AP
5	DM	A	AP	DM	DM	DM	MC	MC	AM	A	DM	AM	AM	DM	DM	D	D	DM	D	AP	DM	A	DM	D	D	AM	DM	D	D	D	D	DM	A	DM	A	DM	DM	D	D	DM	A	D	DM	DM	A	A	AM	AP
6	DM	AM	A	AP	AM	A	D	MC	A	A	DM	AM	AM	DM	D	D	DM	DM	D	D	DM	D	DM	D	D	AM	DM	DM	DM	DM	D	D	AM	DM	A	D	DM	D	D	DM	A	DM	D	DM	AP	A	AM	D
7	MC	AM	A	A	A	A	A	A	AM	AP	DM	AM	AM	DM	D	D	A	DM	A	A	D	A	D	D	A	A	A	A	D	D	AM	A	D	A	D	D	A	A	D	D	AM	D	D	D	A	A	AM	A
8	MC	AM	A	A	A	A	AM	AM	AM	A	DM	AM	A	DM	D	D	A	DM	A	AM	AP	AM	A	DM	D	AM	A	AM	D	DM	A	A	DM	A	D	A	DM	D	D	DM	AM	DM	D	DM	A	A	AM	A
9	MC	AM	A	A	A	AP	MC	MC	AM	A	DM	AM	A	DM	A	D	D	DM	A	A	D	A	D	D	A	AM	AM	AP	D	D	A	DM	AM	DM	A	D	D	D	D	DM	A	D	DM	D	A	A	AM	A
10	MC	A	AP	AP	A	A	MC	MC	A	A	DM	AP	AM	DM	D	D	DM	D	DM	D	D	D	DM	D	D	A	A	A	DM	DM	D	D	A	D	AM	DM	D	D	D	DM	A	D	D	D	DM	AP	AM	D
11	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	A	A	AP	A	A	D	AP	A	MC	A	A	AP	MC	AM	A	A	A	MC	A	DM	A	MC	A	AM	A	A	AM	MC	A	A	AM	MC	MC	MC	DM
12	MC	A	AP	A	A	A	MC	MC	A	A	MC	AM	A	D	AP	D	DM	D	AP	A	D	A	D	D	AP	D	D	DM	D	D	A	DM	A	D	A	D	D	D	D	DM	A	D	D	DM	A	AP	AM	AP
13	MC	A	AP	MC	A	AP	AP	A	A	A	MC	A	A	MC	D	D	DM	D	D	D	D	AP	D	D	D	AP	D	D	D	D	AP	D	A	D	A	D	D	D	DM	D	A	DM	DM	DM	A	AP	AM	AP
14	A	D	D	D	D	MC	D	D	D	D	A	D	DM	AM	A	A	A	A	D	A	A	DM	A	AM	A	D	A	A	AM	A	D	A	DM	AM	D	A	A	A	AM	AM	D	A	A	A	D	D	D	A
15	A	MC	AP	MC	AP	A	MC	MC	MC	MC	A	MC	MC	A	AM	A	A	D	A	A	A	MC	AM	A	A	D	A	A	A	AM	AP	A	D	A	D	A	A	A	A	A	AP	D	A	A	AP	AP	A	A
16	A	MC	MC	AP	AP	AP	D	D	AP	MC	A	D	D	AM	A	AM	A	AP	A	A	A	D	A	DM	A	D	A	A	A	A	AP	A	MC	A	MC	A	A	A	A	A	D	A	A	A	AP	D	AM	A
17	A	MC	AP	MC	MC	AP	MC	MC	MC	MC	AM	MC	MC	A	A	A	AM	A	A	A	AM	MC	AM	D	A	AP	AM	AM	AM	AM	AP	A	MC	AM	MC	AM	AM	AM	AM	AM	D	A	AM	AM	D	D	D	D
18	A	D	D	D	AP	MC	MC	MC	MC	AP	AM	MC	MC	A	D	D	A	AM	D	D	D	MC	A	A	A	MC	A	A	A	A	MC	A	D	A	MC	A	A	A	A	A	D	A	A	A	D	MC	D	D
19	AP	MC	A	AP	MC	A	AP	A	A	AP	MC	AM	DM	AM	AM	AM	AM	DM	AM	AM	AM	AP	AM	D	A	AM	AM	AM	AM	AM	AP	A	D	AM	D	AM	A	A	A	A	A	D	AM	A	AM	A	AM	AM
20	MC	AP	A	AP	A	A	A	A	A	AM	MC	A	D	AM	D	AP	A	A	AP	AM	A	AP	A	D	A	A	A	A	AP	A	AP	A	D	A	D	A	A	A	A	A	D	A	A	A	AP	D	AM	A
21	A	MC	AP	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	A	A	A	A	A	AP	A	AM	MC	AM	D	A	AP	A	A	AM	AM	D	A	D	A	D	A	A	A	A	AM	D	A	A	A	D	D	D	A
22	MC	AM	A	A	A	AM	A	A	AM	A	MC	A	A	D	A	A	D	D	A	D	D	AM	D	D	D	AM	A	A	D	D	AM	A	D	A	D	A	A	A	D	DM	A	D	D	D	A	A	AM	A
23	AM	MC	A	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	A	A	A	A	A	AP	A	A	D	AM	A	A	D	A	A	A	A	D	AM	MC	A	D	A	A	A	A	AM	D	A	A	A	D	D	D	D
24	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	D	D	AM	A	A	A	A	D	A	A	MC	AM	AM	A	D	A	A	A	A	D	A	MC	A	MC	A	A	A	A	AM	D	A	A	A	D	D	D	D
25	A	MC	MC	MC	MC	AP	MC	MC	MC	MC	AM	MC	D	A	A	A	A	A	D	A	A	D	AM	D	AM	D	A	A	A	A	D	AM	D	A	D	A	A	A	A	A	D	A	AM	A	D	D	D	D
26	MC	A	AM	A	A	A	D	MC	A	A	MC	A	AM	DM	D	D	D	D	D	D	D	A	D	D	D	AM	D	D	D	D	D	D	AM	D	AM	D	D	D	D	DM	A	DM	D	DM	D	A	AM	A
27	A	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AM	A	A	A	A	D	A	A	D	AM	A	A	D	AM	A	A	A	D	A	D	AM	D	AM	A	A	A	A	D	A	A	A	D	D	D	D
28	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AM	A	A	A	A	D	A	A	MC	A	A	A	D	A	AM	AM	AM	D	A	D	A	D	A	A	A	A	AM	D	A	A	A	D	D	D	D
29	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AM	A	A	A	A	D	A	A	MC	AM	A	A	MC	A	A	AM	AM	D	A	D	A	D	AM	A	A	A	A	D	A	AM	AM	D	D	D	D
30	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AM	A	A	A	A	D	A	A	MC	AM	A	A	MC	AM	AM	AM	AM	MC	A	MC	A	MC	A	A	A	AM	AM	D	A	A	A	D	D	MC	D
31	MC	AM	A	A	A	A	MC	MC	A	MC	MC	AM	MC	AM	A	A	A	D	AM	AM	D	AM	A	D	D	A	D	A	D	D	AM	A	D	A	MC	D	D	D	D	D	AM	DM	D	D	AM	A	A	A
32	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	D	D	A	A	A	A	A	D	A	A	MC	A	D	A	D	A	A	A	A	D	AM	D	A	D	A	A	A	A	A	D	A	A	A	D	D	D	D
33	MC	A	A	A	A	A	A	A	A	A	MC	A	A	DM	D	D	D	A	D	D	D	MC	D	D	D	AM	DM	D	D	D	MC	D	AM	D	AM	DM	DM	DM	DM	DM	AM	DM	DM	DM	AP	A	AM	A
34	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AM	A	A	A	A	D	A	A	MC	A	A	A	D	A	A	A	A	D	AM	MC	A	MC	A	A	A	A	A	D	A	AM	AM	D	D	AP	AP
35	MC	A	A	MC	A	A	A	A	A	A	MC	A	A	DM	DM	DM	DM	A	D	D	D	D	D	D	MC	AM	D	D	D	D	D	D	AM	D	AM	D	D	D	D	D	AM	D	D	D	D	D	AM	D
36	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AM	A	A	A	A	D	A	A	MC	A	A	A	D	A	A	A	AM	D	A	D	AM	MC	AM	A	A	A	A	D	A	AM	A	D	MC	AP	A
37	A	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	A	A	A	A	A	D	A	A	D	A	A	A	MC	A	A	A	A	D	A	MC	A	MC	AM	AM	AM	A	AM	D	A	A	AM	MC	D	D	D
38	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	A	A	A	A	A	D	A	A	MC	A	A	A	MC	A	A	A	A	MC	AM	MC	AM	MC	AM	AM	AM	A	AM	D	A	A	AM	D	D	MC	D
39	A	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AM	A	A	AM	A	D	A	A	MC	AM	A	A	MC	A	A	A	A	MC	A	MC	A	MC	A	A	A	AM	AM	D	A	AM	AM	D	D	D	D
40	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	A	A	A	A	A	MC	A	A	MC	AM	A	A	MC	A	A	A	A	D	A	D	A	D	A	A	A	A	A	D	A	AM	AM	D	D	D	D
41	MC	A	A	AP	AM	AM	AP	AP	A	A	MC	A	A	MC	MC	A	DM	MC	A	AP	D	MC	D	D	D	AP	D	D	D	D	A	D	A	D	AM	A	DM	DM	DM	DM	AM	DM	DM	DM	A	AP	AM	AM
42	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AM	D	A	A	A	MC	A	A	MC	AM	A	A	MC	A	A	A	A	MC	AM	MC	A	MC	A	A	A	AM	AM	D	AM	AM	AM	D	D	D	D
43	A	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AM	A	A	A	A	MC	A	A	MC	AM	A	A	MC	MC	A	A	A	MC	A	MC	AM	MC	A	A	A	A	A	MC	A	AM	AM	D	D	D	D
44	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AM	A	A	A	A	AP	A	A	MC	AM	A	A	MC	A	A	A	A	AP	A	MC	A	MC	A	A	A	A	AM	D	A	A	AM	AP	D	D	D
45	MC	A	A	AP	A	A	AP	AP	A	MC	MC	A	AP	D	A	A	A	MC	AM	A	D	AP	D	D	D	A	D	D	D	D	AM	AP	MC	A	MC	D	A	A	D	D	AM	D	MC	D	AM	A	AM	AM
46	MC	A	A	A	A	A	MC	MC	A	A	MC	AM	AM	D	D	D	D	D	A	AP	D	AM	D	D	D	D	D	D	DM	DM	AM	D	A	D	AM	D	D	D	DM	MC	D	D	D	D	A	AM	AM	A
47	MC	A	A	A	A	MC	MC	MC	A	A	MC	AM	AM	D	D	D	D	A	D	A	D	MC	D	D	D	AM	D	D	D	D	A	D	A	D	A	D	D	D	D	DM	AM	D	D	DM	AP	AP	AM	D
48	AP	A	A	A	A	A	A	A	A	A	MC	AM	D	AM	A	A	AM	D	A	A	A	AP	A	D	A	AM	A	A	A	A	AP	A	D	A	D	A	A	A	A	A	D	A	A	A	A	AP	AM	AM

Table B6 – Frequency of occurrence of expert #3's responses.

Expert Number: 3

Occurrence of Answers Concerning Activation Characteristics:

Concept ACTIVATING	NC	AM	A	AP	DM	D	DP	Concept BEING ACTIVATED	NC	AM	A	AP	DM	D	DP
1	19	9	16	2	0	2	0	1	19	13	12	2	2	0	0
2	6	3	14	3	10	12	0	2	24	6	15	1	0	2	0
3	5	7	12	0	18	6	0	3	20	2	17	7	0	2	0
4	7	3	17	2	6	13	0	4	24	0	13	8	1	2	0
5	2	5	8	3	18	12	0	5	22	3	18	3	1	1	0
6	1	7	7	2	16	15	0	6	23	2	17	5	1	0	0
7	1	7	21	1	3	15	0	7	33	1	6	4	0	4	0
8	1	11	17	1	10	8	0	8	34	1	9	2	0	2	0
9	3	7	16	2	7	13	0	9	24	5	17	1	0	1	0
10	3	3	10	4	10	18	0	10	25	1	16	5	0	1	0
11	19	6	17	3	2	1	0	11	16	19	6	0	7	0	0
12	4	2	14	6	5	17	0	12	21	11	11	1	0	4	0
13	4	1	11	8	5	19	0	13	21	8	10	1	2	6	0
14	1	6	21	0	3	17	0	14	4	17	12	0	9	6	0
15	9	3	25	6	0	5	0	15	1	2	28	1	4	12	0
16	5	3	24	7	1	8	0	16	0	2	28	2	1	15	0
17	12	16	10	4	0	6	0	17	0	5	28	0	8	7	0
18	11	2	20	2	0	13	0	18	3	2	25	2	6	10	0
19	3	20	13	6	2	4	0	19	4	3	11	5	3	22	0
20	2	4	27	8	0	7	0	20	1	4	30	4	1	8	0
21	11	5	21	3	0	8	0	21	0	3	24	1	5	15	0
22	2	7	22	0	1	16	0	22	22	5	6	5	2	8	0
23	11	5	22	1	0	9	0	23	0	16	14	0	6	12	0
24	12	6	20	0	0	10	0	24	0	3	17	0	3	25	0
25	9	5	20	1	0	13	0	25	1	1	29	3	0	14	0
26	3	6	11	0	4	24	0	26	12	12	7	4	0	13	0
27	11	6	20	0	0	11	0	27	1	7	27	0	4	9	0
28	12	7	19	0	0	10	0	28	0	5	30	1	2	10	0
29	13	9	17	0	0	9	0	29	0	7	20	1	3	17	0
30	17	10	16	0	0	5	0	30	0	9	19	0	5	15	0
31	7	9	16	0	1	15	0	31	9	5	6	8	0	20	0
32	10	3	22	0	0	13	0	32	0	6	26	1	5	10	0
33	4	5	14	1	10	14	0	33	13	7	8	0	3	17	0
34	14	6	20	2	0	6	0	34	0	8	25	0	4	11	0
35	4	5	11	0	4	24	0	35	17	7	8	0	0	16	0
36	14	7	20	1	0	6	0	36	0	7	24	0	5	12	0
37	15	5	21	0	0	7	0	37	0	4	27	0	7	10	0
38	17	9	17	0	0	5	0	38	0	3	28	0	2	15	0
39	16	8	18	0	0	6	0	39	0	6	22	0	5	15	0
40	14	5	21	0	0	8	0	40	1	14	14	0	13	6	0
41	6	6	12	6	8	10	0	41	3	9	11	1	0	24	0
42	17	10	15	0	0	6	0	42	0	1	26	0	8	13	0
43	19	6	19	0	0	4	0	43	1	11	17	0	6	13	0
44	15	6	20	3	0	4	0	44	0	11	17	0	12	8	0
45	7	6	15	6	0	14	0	45	2	4	10	8	1	23	0
46	5	7	11	1	3	21	0	46	5	1	13	7	0	22	0
47	6	5	11	2	2	22	0	47	4	22	3	2	0	17	0
48	1	6	31	4	0	6	0	48	0	4	15	5	2	22	0
Sum:	410	305	822	101	149	517	0	Sum:	410	305	822	101	149	517	0
% :	17.8	13.2	35.7	4.4	6.5	22.4	.0	% :	17.8	13.2	35.7	4.4	6.5	22.4	.0

Table B7 – Expert #4's responses.

Expert Number: 4

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1	AM	NC	NC	NC	NC	NC	NC	NC	NC	NC	AP	NC	NC	AP	NC	NC	AP	A	NC	NC	AP	NC	A	NC	NC	NC	AP	A	AM	AM	NC	AP	NC	AP	DP	A	NC	NC	A	AM	D	AP	A	A	NC	NC	NC	NC
2	NC	AM	NC	NC	NC	NC	NC	NC	NC	NC	NC	AP	A	NC	NC	NC	NC	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AP	NC
3	NC	NC	AM	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AM	NC	NC	NC	NC	NC	NC	NC	NC	AM	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
4	NC	NC	NC	AM	NC	NC	NC	NC	NC	NC	NC	AP	NC	NC	NC	NC	NC	NC	AP	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
5	NC	NC	AP	NC	AM	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
6	NC	NC	NC	NC	NC	AM	NC	NC	NC	AP	NC	AP	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
7	NC	NC	NC	AP	NC	NC	AM	A	A	AP	NC	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
8	NC	NC	NC	NC	NC	NC	A	AM	AP	NC	NC	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AP
9	NC	AP	NC	NC	NC	NC	NC	NC	AM	NC	NC	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
10	NC	A	NC	NC	NC	NC	NC	NC	NC	AM	NC	NC	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
11	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	AM	NC	NC	AP	NC	NC	NC	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC
12	NC	A	NC	NC	NC	NC	NC	NC	AP	NC	NC	AM	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
13	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AM	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
14	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AM	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AP	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
15	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AM	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AP	NC	AP	NC	AP	NC	NC	NC	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
16	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AM	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
17	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AM	NC	NC	AP	AP	NC	NC	NC	NC	NC	NC	AP	NC	NC	NC	AP	DM	AM	NC	A	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
18	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	D	AP	NC	NC	NC	AM	NC	NC	NC	NC	NC	NC	NC	NC	AP	A	A	NC	NC	NC	NC	NC	NC	AP	NC	NC	NC	NC	NC	A	AP	NC	NC	NC	NC	NC
19	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AM	A	NC	NC	NC	NC	NC	NC	NC	AP	NC	NC	AP	AP	DP	AP	NC	AP	NC	NC	NC	NC	AP	NC	NC	NC	A	NC	NC	AP
20	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AM	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AP	NC	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
21	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AM	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
22	NC	NC	NC	AM	NC	NC	NC	NC	AM	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AM	NC	NC	NC	AP	NC	NC	NC	NC	AP	A	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
23	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AM	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
24	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	D	NC	NC	NC	NC	NC	NC	NC	AM	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
25	A	DP	NC	D	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	A	NC	NC	AP	NC	AM	DP	AP	A	A	A	NC	AP	DP	A	NC	AP	NC	NC	NC	A	NC	NC	A	A	NC	NC	NC	NC
26	NC	AP	AP	NC	NC	NC	NC	NC	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AM	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	DM	NC	D	NC	NC	NC	NC	DM	NC
27	AP	D	DP	DP	NC	NC	NC	NC	NC	NC	AP	DP	NC	NC	NC	NC	NC	AM	NC	NC	NC	NC	NC	NC	NC	DP	AM	AP	A	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	DP	A	NC	NC	NC	NC	NC	NC
28	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AP	NC	NC	NC	NC	NC	NC	AP	AM	AP	AP	NC	AP	NC	NC	NC	NC	NC	NC	NC	AP	NC	AP	NC	NC	NC	NC	NC	NC
29	A	D	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AP	AM	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	AP	NC	NC	NC	NC	NC	NC	NC	NC
30	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AP	AP	AM	NC	AP	NC	AP	NC	AP	NC	NC	NC	AP	NC	NC	NC	NC	NC	NC	NC	NC
31	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AM	NC	NC	NC	NC	AP	NC	NC	DM	NC	AP	NC	NC	NC	NC	NC	NC	NC
32	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	AP	NC	NC	NC	NC	NC	NC	A	A	A	NC	AM	DM	A	NC	A	NC	NC	NC	NC	NC	NC	AM	A	NC	NC	NC	NC
33	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AM	DP	NC	DP	NC	NC	NC	DP	NC	NC	NC	NC	NC	NC	NC	NC
34	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AM	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
35	NC	AP	NC	NC	NC	AP	NC	NC	NC	NC	NC	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	D	D	NC	DP	NC	NC	AM	D	NC	NC	D	D	NC	D	D	NC	NC	NC	NC	NC
36	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	A	DP	A	NC	AM	NC	NC	NC	AP	NC	NC	A	NC	NC	NC	NC	NC
37	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AP	NC	NC	NC	NC	NC	AP	NC	NC	NC	NC	NC	NC	AP	NC	A	DP	A	NC	AP	AM	AM	NC	AP	NC	NC	AP	NC	NC	NC	NC	NC
38	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AM	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
39	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	A	NC	NC	NC	NC	NC	NC	NC	NC	AP	NC	NC	NC	NC	NC	D	AP	NC	A	NC	NC	AM	NC	NC	AP	AP	NC	NC	NC	NC	NC
40	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	A	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	AM	NC	NC	NC	NC	NC	NC	NC	NC
41	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	D	A	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	AM	D	NC	NC	AP	NC	NC	NC
42	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	AP	NC	NC	NC	AM	NC	NC	NC	NC	NC	NC	NC	NC	A	A	A	A	NC	AP	NC	NC	NC	NC	NC	NC	AM	AP	NC	AM	NC	NC	NC	NC	NC	NC
43	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AP	NC	AP	NC	AM	D	AP	D	A	NC	NC	NC	NC	NC	NC	AM	AP	NC	NC	NC	NC
44	AM	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	A	NC	NC	A	NC	NC	NC	NC	A	A	A	NC	A	DM	A	NC	A	NC	NC	NC	AM	NC	A	AP	AM	NC	NC	NC	AM
45	NC	NC	A	NC	NC	NC	NC	NC	AP	NC	DM	NC	NC	NC	NC	NC	NC	NC	AM	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AM	NC	NC	A	NC	NC	NC	NC	DM	NC	AM	D	NC	NC	AM	NC	NC	A
46	DM	AM	AM	A	NC	NC	NC	NC	A	NC	DM	A	A	D	NC	NC	D	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	DM	DM	NC	NC	NC	NC	NC	NC	NC	NC	DM	DM	NC	DM	D	DP	NC	AM	A	NC
47	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	D	NC	D	NC	NC	NC	NC	NC	DP	NC	NC	DP	AP	D	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AM	NC
48	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	A	NC	A	NC	A	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	AM	DM	AM	DM	NC	NC	NC	A	NC	D	NC	NC	NC	NC	NC	NC	AM

Table B8 – Frequency of occurrence of expert #4's responses.

Expert Number: 4

Occurrence of Answers Concerning Activation Characteristics:

Concept	A C T I V A T I N G							Concept	B E I N G A C T I V A T E D						
	NC	AM	A	AP	DM	D	DP		NC	AM	A	AP	DM	D	DP
1	27	4	7	8	0	1	1	1	35	2	3	7	1	0	0
2	43	1	1	3	0	0	0	2	38	2	2	3	0	2	1
3	45	3	0	0	0	0	0	3	42	2	1	2	0	0	1
4	43	1	2	2	0	0	0	4	42	2	1	1	0	1	1
5	46	1	0	1	0	0	0	5	47	1	0	0	0	0	0
6	44	1	0	3	0	0	0	6	46	1	0	1	0	0	0
7	42	1	2	3	0	0	0	7	46	1	1	0	0	0	0
8	43	1	1	3	0	0	0	8	46	1	1	0	0	0	0
9	45	1	0	2	0	0	0	9	40	2	2	4	0	0	0
10	45	1	1	1	0	0	0	10	45	1	0	2	0	0	0
11	42	1	0	5	0	0	0	11	41	1	2	2	2	0	0
12	45	1	1	1	0	0	0	12	37	1	1	8	0	0	1
13	46	1	1	0	0	0	0	13	42	1	2	2	0	1	0
14	45	1	0	2	0	0	0	14	41	1	1	4	0	1	0
15	43	1	0	4	0	0	0	15	47	1	0	0	0	0	0
16	47	1	0	0	0	0	0	16	45	1	1	0	0	1	0
17	39	2	1	5	1	0	0	17	37	1	7	2	0	1	0
18	38	1	4	4	0	1	0	18	39	3	3	2	0	1	0
19	37	1	2	7	0	0	1	19	42	2	3	1	0	0	0
20	45	1	0	2	0	0	0	20	39	1	6	2	0	0	0
21	46	1	1	0	0	0	0	21	42	1	1	3	0	1	0
22	41	3	2	2	0	0	0	22	46	1	1	0	0	0	0
23	46	1	1	0	0	0	0	23	38	1	6	2	0	1	0
24	45	1	0	1	0	1	0	24	47	1	0	0	0	0	0
25	29	1	10	4	0	1	3	25	47	1	0	0	0	0	0
26	41	1	0	3	2	1	0	26	42	2	1	1	0	0	2
27	33	2	3	4	0	1	5	27	41	1	1	5	0	0	0
28	39	1	0	8	0	0	0	28	34	1	6	7	0	0	0
29	41	1	2	3	0	1	0	29	32	2	7	4	1	1	1
30	41	1	0	6	0	0	0	30	32	2	5	7	1	1	0
31	42	1	2	2	1	0	0	31	42	2	2	2	0	0	0
32	36	2	7	2	1	0	0	32	30	3	4	9	0	0	2
33	43	1	0	1	0	0	3	33	36	1	0	1	4	2	4
34	46	1	1	0	0	0	0	34	30	3	7	6	0	1	1
35	36	1	0	3	0	7	1	35	43	2	0	0	1	1	1
36	40	1	4	2	0	0	1	36	31	1	7	7	0	1	1
37	37	2	2	6	0	0	1	37	46	1	0	1	0	0	0
38	47	1	0	0	0	0	0	38	46	2	0	0	0	0	0
39	39	1	3	4	0	1	0	39	39	2	2	1	3	1	0
40	43	1	4	0	0	0	0	40	33	3	2	6	2	1	1
41	41	1	3	1	0	2	0	41	41	2	0	2	0	2	1
42	36	3	5	4	0	0	0	42	36	1	3	3	1	4	0
43	38	2	2	4	0	2	0	43	36	2	4	4	0	2	0
44	32	4	10	1	1	0	0	44	42	1	3	1	0	0	1
45	36	4	4	1	2	1	0	45	45	1	1	1	0	0	0
46	28	3	6	0	7	3	1	46	47	1	0	0	0	0	0
47	41	1	0	1	0	3	2	47	44	1	1	1	1	0	0
48	35	3	7	0	2	1	0	48	43	2	1	2	0	0	0
Sum:	1948	72	102	119	17	27	19	Sum:	1948	72	102	119	17	27	19
% :	84.5	3.1	4.4	5.2	.7	1.2	.8	% :	84.5	3.1	4.4	5.2	.7	1.2	.8

Table B9 – Expert #5's responses.

Expert Number: 5

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1	A	DM	D	D	NC	NC	NC	NC	NC	NC	A	NC	NC	A	NC	NC	AP	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AP	NC	NC	NC	NC	NC	AM	NC	NC	NC	NC	NC	NC	NC	NC
2	NC	A	NC	NC	NC	A	NC	NC	AM	NC	NC	AM	A	DM	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AP	NC	NC	NC	NC	NC	A	D	NC	D	NC	NC	NC	D	NC	NC	NC	NC	NC	NC	A	NC
3	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AM	NC
4	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
5	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC
6	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	D	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	D	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AM	NC
7	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	AM	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	D	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A
8	NC	NC	A	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	D	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A
9	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	D	NC	NC	NC	NC	A	NC
10	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AM	NC	NC	NC	NC	NC	NC	D	NC	NC	NC	NC	NC	NC	NC	NC	NC	D	NC	NC	NC	NC	NC	NC	NC	NC	D	NC	NC	NC	D	NC	NC	NC	NC	NC
11	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	A	NC	NC	NC	D	D
12	NC	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	D	NC	NC	NC	NC	NC	NC	NC	NC
13	NC	NC	NC	NC	NC	NC	NC	NC	NC	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	D	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
14	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
15	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AM	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC
16	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	D	NC	NC	NC	NC	NC	NC	A	NC
17	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	A	NC	NC	NC	A	NC	NC	NC	NC	AP	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC
18	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	AM	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	D	NC	NC	NC	NC	NC	NC	D
19	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	D	NC	NC	A	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	A	AM
20	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	DP	NC	NC	NC	NC	NC	NC	NC	NC	NC	AP
21	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	D	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC
22	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	AP	NC	NC	NC	NC	NC	NC	NC	NC	AP	NC	NC	NC
23	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AP	NC	NC	NC	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AP	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	A	NC	NC	NC	NC	NC
24	A	D	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	DM	NC
25	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	A	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	A	NC	NC	A	NC	NC	D	D	NC
26	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	D	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	D	NC	NC	NC	NC	A	NC
27	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	AP	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	D	AP	NC	NC	NC	NC	NC	NC
28	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
29	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	AM	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	D	NC	NC	NC	NC	NC	NC	NC
30	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	D	A	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC
31	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	D	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	D	NC	NC	NC	NC	NC	A	NC	NC	NC
32	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	DM	A	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC
33	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	DM	NC	DM	NC	NC	NC	NC	NC	NC	NC	NC	DM	NC	NC	NC	NC	NC
34	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	DM	NC	NC	NC	NC	NC	NC	NC	NC	NC	AP	NC	NC	NC	NC	NC
35	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	AP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	D	NC	NC	D	NC	NC	D	NC	NC	NC	NC	NC	NC
36	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	A	A	NC	NC	NC	D	A	NC	NC	NC	NC	A	NC	NC	NC	A	NC	NC	NC	NC	NC
37	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	D	A	NC	A	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
38	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
39	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC
40	A	D	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
41	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	DM	NC	NC	NC	NC	NC	NC	NC	NC	A
42	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	A	NC	NC	NC	NC	D
43	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	D	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
44	A	D	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	A	NC	NC	NC	NC	NC	NC
45	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	D	NC	NC	D	NC	NC	NC	NC	NC	NC	NC	A	NC
46	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	DM	NC	NC	NC	NC	NC	NC	AM	NC
47	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	D	NC	NC	NC	NC	NC	NC	NC	NC	NC	D	NC	NC	NC	NC	NC	NC	D	NC	NC	D	NC	NC	NC	NC	NC
48	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	A	NC

Table B10 – Frequency of occurrence of expert #5's responses.

Expert Number: 5

Occurrence of Answers Concerning Activation Characteristics:

Concept	ACTIVATING NC	AM	A	AP	DM	D	DP	Concept	BEING ACTIVATED NC	AM	A	AP	DM	D	DP
1	38	1	3	3	1	2	0	1	40	0	7	1	0	0	0
2	36	2	5	1	1	3	0	2	41	0	2	1	1	3	0
3	45	1	2	0	0	0	0	3	44	0	3	0	0	1	0
4	46	0	2	0	0	0	0	4	46	0	0	1	0	1	0
5	46	0	2	0	0	0	0	5	46	0	2	0	0	0	0
6	44	1	1	0	0	2	0	6	47	0	1	0	0	0	0
7	44	1	2	0	0	1	0	7	47	0	1	0	0	0	0
8	44	0	2	1	0	1	0	8	47	0	1	0	0	0	0
9	45	0	2	0	0	1	0	9	47	1	0	0	0	0	0
10	43	1	0	0	0	4	0	10	47	0	0	1	0	0	0
11	40	0	6	0	0	2	0	11	43	0	3	1	0	1	0
12	46	0	0	1	0	1	0	12	44	2	1	1	0	0	0
13	46	0	0	1	0	1	0	13	46	1	1	0	0	0	0
14	47	0	1	0	0	0	0	14	46	0	1	0	1	0	0
15	45	1	2	0	0	0	0	15	46	0	0	0	0	2	0
16	46	0	1	0	0	1	0	16	48	0	0	0	0	0	0
17	43	0	4	1	0	0	0	17	42	1	3	2	0	0	0
18	42	1	3	0	0	2	0	18	44	0	3	1	0	0	0
19	41	1	5	0	0	1	0	19	47	0	1	0	0	0	0
20	46	0	0	1	0	0	1	20	44	0	2	0	0	2	0
21	45	0	2	0	0	1	0	21	47	0	0	1	0	0	0
22	45	0	1	2	0	0	0	22	47	0	1	0	0	0	0
23	43	0	2	3	0	0	0	23	40	0	7	0	0	1	0
24	44	0	2	0	1	1	0	24	48	0	0	0	0	0	0
25	39	0	7	0	0	2	0	25	48	0	0	0	0	0	0
26	44	0	2	0	0	2	0	26	47	0	1	0	0	0	0
27	40	0	4	3	0	1	0	27	44	2	1	1	0	0	0
28	46	0	2	0	0	0	0	28	42	0	6	0	0	0	0
29	44	1	2	0	0	1	0	29	40	0	6	0	0	2	0
30	45	0	2	0	0	1	0	30	46	0	1	0	0	1	0
31	44	0	2	0	0	2	0	31	47	0	1	0	0	0	0
32	45	0	2	0	1	0	0	32	43	0	3	1	1	0	0
33	45	0	0	0	3	0	0	33	38	0	1	0	2	7	0
34	45	0	1	1	1	0	0	34	41	0	4	1	1	1	0
35	44	0	0	1	0	3	0	35	46	0	2	0	0	0	0
36	40	0	7	0	0	1	0	36	41	0	2	1	0	4	0
37	44	0	3	0	0	1	0	37	46	0	1	1	0	0	0
38	46	0	2	0	0	0	0	38	46	0	1	0	0	0	1
39	46	0	2	0	0	0	0	39	36	0	7	0	1	4	0
40	45	0	2	0	0	1	0	40	38	1	4	0	1	4	0
41	46	0	1	0	1	0	0	41	45	0	0	0	0	3	0
42	44	0	3	0	0	1	0	42	42	0	2	1	0	3	0
43	46	0	1	0	0	1	0	43	34	0	10	1	1	2	0
44	42	0	5	0	0	1	0	44	48	0	0	0	0	0	0
45	44	0	2	0	0	2	0	45	46	0	1	1	0	0	0
46	45	1	1	0	1	0	0	46	47	0	0	0	0	1	0
47	44	0	0	0	0	4	0	47	34	3	8	0	1	2	0
48	46	0	2	0	0	0	0	48	40	1	3	1	0	3	0
Sum:	2109	12	105	19	10	48	1	Sum:	2109	12	105	19	10	48	1
% :	91.5	.5	4.6	.8	.4	2.1	.0	% :	91.5	.5	4.6	.8	.4	2.1	.0

Table B11 – Expert #6's responses.

Expert Number: 6

	1	2	3	4	5	6	7	8	9	10	11	12
1	A	MC	D	MC	MC	MC	MC	MC	MC	MC	AM	MC
2	MC	AM	A	AP	A	A	AP	AP	AM	A	DM	AM
3	DM	AM	AM	A	A	A	A	A	AM	AM	D	AM
4	DM	A	D	AM	AP	D	MC	MC	AM	AP	DM	AM
5	MC	MC	A	AP	AM	A	DM	MC	A	AP	MC	MC
6	DP	AP	AM	D	D	AM	MC	MC	A	MC	A	AM
7	MC	MC	MC	A	A	A	AM	A	AM	A	DM	AM
8	D	A	A	AM	D	AP	AP	AM	A	A	D	A
9	DM	AM	A	AM	AM	AP	A	AP	AM	AP	DM	AM
10	DM	A	AM	AP	MC	A	A	MC	A	AM	DM	AM
11	AM	DM	DM	DM	DM	D	D	D	DM	DM	AM	DM
12	MC	A	A	A	AP	A	AP	AP	A	AP	D	AM
13	DM	A	A	A	A	A	A	A	AP	AM	DM	AM
14	A	DM	DM	D	D	MC	MC	A	MC	DM	A	DM
15	A	D	D	D	D	D	MC	MC	MC	DP	A	D
16	MC	MC	MC	MC	MC	A	MC	MC	MC	MC	MC	MC
17	AM	DM	DM	DM	DM	MC	MC	MC	MC	MC	A	D
18	A	D	D	D	MC	MC	MC	MC	MC	MC	A	D
19	MC	MC	A	A	A	MC	A	A	MC	MC	DM	MC
20	MC	MC	MC	MC	MC	A	A	MC	MC	MC	A	D
21	A	D	D	MC	MC	MC	MC	MC	MC	MC	A	DM
22	A	D	A	AM	A	D	A	A	A	A	D	D
23	A	D	D	D	D	D	D	D	D	DP	A	MC
24	AM	DM	DM	DM	DM	MC	MC	MC	MC	MC	AM	DM
25	AM	DM	DM	DM	DM	DM	DM	MC	MC	DM	AM	DM
26	DM	AM	AM	A	A	AP	DP	DP	AM	A	D	AM
27	AM	DM	DM	DM	DM	DM	DM	DM	DM	DM	AM	DM
28	AM	DM	DM	DM	DM	DM	DM	DM	DM	DM	AM	DM
29	AM	DM	DM	DM	DM	DM	DM	DM	DM	DM	AM	DM
30	AM	DM	DM	DM	DM	DM	DM	DM	DM	DM	AM	DM
31	D	A	D	D	AM	AP	A	A	A	AP	DM	MC
32	A	D	D	D	D	D	AP	AP	MC	D	A	D
33	D	AP	A	A	AP	A	MC	MC	A	AP	D	AP
34	A	D	D	D	D	DM	DP	MC	MC	MC	A	D
35	D	A	AM	AP	AP	AP	MC	MC	MC	AP	D	AM
36	A	DM	DM	D	D	D	D	D	D	D	A	DM
37	A	D	D	D	D	D	D	D	D	D	A	DM
38	A	D	DM	D	DP	DP	DP	DP	DP	DP	A	DM
39	A	D	DP	DP	DP	DP	DP	DP	DP	DP	A	DM
40	A	D	D	DP	DP	DP	DP	DP	DP	DP	A	DM
41	D	A	AP	AP	AP	AP	AP	AP	AP	AP	D	A
42	A	D	DM	DM	D	DM	D	DM	DM	D	A	DM
43	A	D	DM	D	D	D	D	DP	DP	DP	A	DM
44	AM	DM	DM	DM	DM	DM	AM	AM	D	DP	A	DM
45	D	AP	AM	AM	AM	AP	AP	A	AM	AP	DM	AP
46	DM	AM	AM	AM	AM	AM	A	A	AM	AM	DM	AM
47	DM	AM	AM	AM	AM	A	AP	AP	AP	AP	DM	AM
48	DM	AP	A	AM	AM	AP	AM	AM	AM	AP	DM	AM

	13	14	15	16	17	18	19	20	21	22	23	24
1	MC	A	A	MC	AM	AM	A	AP	A	MC	AM	A
2	AM	DM	DM	MC	DM	A	A	A	D	A	DM	DM
3	AM	DM	DM	MC	DM	AM	DM	D	D	MC	D	DM
4	MC	A	A	MC	A	D	AM	AM	A	AM	A	MC
5	MC	MC	MC	MC	MC	AP	MC	MC	AP	AP	MC	MC
6	AP	DM	DM	MC	A	A	D	D	A	MC	A	MC
7	A	MC	A	MC	A	MC	AM	AM	A	AM	AP	MC
8	D	A	A	MC	AP	AM	AM	AM	AM	AM	A	MC
9	AM	DM	MC	MC	D	D	AP	A	D	AM	DM	MC
10	AM	DM	DM	DM	DM	D	D	DM	DM	A	DM	DM
11	DM	A	A	A	AM	AM	A	A	A	DM	AM	AP
12	A	D	A	MC	A	A	AP	MC	A	AM	DM	MC
13	AM	DM	DM	MC	D	D	DM	DM	D	A	DM	DM
14	DM	AM	DM	MC	AM	A	MC	A	AM	DM	AM	AM
15	D	A	AM	AM	AM	A	A	A	A	D	AM	A
16	MC	MC	MC	MC	A	A	MC	MC	A	MC	A	A
17	MC	MC	A	A	AM	A	A	A	AM	MC	AM	A
18	D	A	A	MC	A	AM	MC	MC	A	MC	AM	AM
19	MC	MC	MC	MC	AM	D	AM	AM	AM	A	A	MC
20	MC	MC	A	A	A	A	A	AM	A	A	AM	MC
21	DM	AM	A	A	AM	A	AP	AP	AM	D	A	AM
22	D	A	A	MC	MC	MC	AM	AM	D	AM	D	MC
23	D	A	A	A	A	A	AP	A	AM	DM	AM	AM
24	DM	AM	A	AM	A	A	MC	AP	A	MC	AM	AM
25	D	A	A	A	A	A	A	AP	A	D	AM	AM
26	A	DM	DM	MC	DM	AM	D	A	A	AM	A	DM
27	DM	AM	AM	AM	AM	AM	AP	A	AM	DM	AM	MC
28	DM	AM	AM	AM	AM	AM	A	A	A	DM	AM	MC
29	DM	AM	A	A	A	A	A	A	A	DM	AM	MC
30	DM	AM	AM	AM	A	A	A	A	A	MC	A	MC
31	D	A	AM	AM	AM	DM	AM	AM	A	A	A	MC
32	D	AP	A	AM	AM	A	AP	AP	A	D	A	MC
33	A	DM	D	D	DM	MC	D	D	D	DM	DM	DM
34	D	A	AM	AM	A	A	D	AM	AM	DM	AM	A
35	AM	DM	A	MC	A	D	D	DM	DM	AP	A	MC
36	D	A	A	A	AM	A	MC	A	A	D	AM	A
37	D	AP	A	A	A	A	MC	A	AM	MC	A	A
38	AP	DP	A	MC	AM	AM	MC	MC	AM	MC	AM	A
39	D	AP	A	A	AM	AM	MC	A	A	MC	AM	A
40	D	A	A	A	A	A	D	A	A	DM	AM	A
41	A	D	A	A	A	DM	AM	AM	A	AM	AM	MC
42	DM	AM	AM	A	AM	AM	DM	A	AM	DM	A	A
43	D	A	A	A	AM	AM	DM	D	AM	DM	AM	MC
44	D	A	AM	A	AM	A	MC	A	AM	MC	AM	MC
45	MC	MC	DM	MC	DM	DM	AM	AM	D	AP	A	MC
46	AM	DM	DM	DM	DM	DM	MC	MC	DM	AM	DM	MC
47	AM	DM	DM	MC	DM	DM	DM	DM	DM	MC	DM	DM
48	AM	DM	AM	MC	DM	DM	AM	AM	A	AM	A	MC

	25	26	27	28	29	30	31	32	33	34	35	36
1	AP	MC	MC	A	AP	AP	MC	A	D	A	MC	AM
2	MC	A	D	D	D	D	D	D	AM	D	A	DM
3	MC	AM	MC	DM	DM	DM	MC	MC	AM	DM	AM	DM
4	MC	A	MC	MC	MC	MC	AM	A	D	AM	DM	A
5	MC	AM	MC	MC	MC	AM	A	MC	MC	MC	AM	MC
6	DM	A	D	DM	D	DM	DP	AM	AP	A	MC	D
7	MC	AP	D	DM	DM	DM	D	A	D	AP	AP	A
8	MC	AM	DM	AM	D	DM	AM	MC	D	A	A	AM
9	MC	AM	DM	DM	DM	DM	A	DM	AM	DM	AM	DM
10	D	A	D	D	DM	DM	DM	DM	DM	DM	AM	DM
11	A	DM	A	A	AM	AM	DM	AM	DM	AM	DM	AM
12	A	A	DM	DM	DM	MC	AP	A	D	A	D	DM
13	MC	A	DM	DM	DM	DM	MC	DM	A	DM	AM	DM
14	A	DM	AM	AM	AM	AM	DM	AM	DM	AM	DM	AM
15	A	D	A	A	AM	AM	DM	AM	D	AM	DM	AM
16	MC	MC	MC	MC	MC	MC	MC	A	MC	A	D	A
17	A	MC	A	A	A	A	MC	A	DM	AM	DM	AM
18	AM	DM	AM	AM	AM	AM	D	AM	D	A	D	A
19	A	A	MC	AM	A	A	AM	A	DM	AM	AM	AM
20	AM	MC	A	A	A	A	AM	AM	DM	AM	DM	AM
21	A	D	A	A	A	A	D	AM	DM	AM	DM	AM
22	A	AM	A	A	A	A	AM	A	D	AM	DM	AM
23	AM	MC	AM	AM	AM	AM	DM	AM	DM	AM	DM	AM
24	AM	DM	A	A	AM	AM	DM	A	DM	AM	DM	A
25	AM	DM	AM	AM	AM	AM	MC	A	D	A	D	A
26	DM	AM	DM	DM	DM	DM	D	A	A	D	A	A
27	A	DM	AM	AM	AM	AM	MC	AM	DM	AM	DM	AM
28	AM	DM	AM	AM	AM	AM	DP	AM	D	AM	DM	AM
29	AM	DM	AM	AM	AM	AM	DM	AM	A	AM	DM	AM
30	A	D	A	A	AM	AM	DM	AM	DM	AM	DM	AM
31	A	AM	D	A	A	A	AM	A	A	A	D	A
32	AM	D	AM	AM	A	A	MC	AM	AM	AM	DM	AM
33	D	D	D	DM	DM	DM	MC	DM	AM	DM	A	DM
34	A	D	A	A	AM	AM	DM	AM	DM	AM	DM	AM
35	D	AM	DM	DM	DM	DM	MC	D	AM	DM	AM	D
36	AM	DM	AM	AM	AM	AM	DM	AM	DM	AM	DM	AM
37	A	MC	A	A	A	A	MC	A	DM	AM	DM	AM
38	AM	MC	A	A	A	A	MC	A	DM	AM	DM	AM
39	A	MC	AM	A	AM	AM	MC	A	DM	AM	DM	AM
40	AM	DM	AM	AM	AM	AM	DM	AM	DM	AM	DM	AM
41	A	MC	DM	AP	AP	AP	AM	AP	AP	AM	AP	A
42	A	DM	AM	AM	AM	AM	DM	AM	DM	AM	DM	AM
43	AM	DM	AM	A	AM	AM	DM	A	D	AM	DM	AM
44	AM	DM	AM	A	AM	AM	DM	AM	DM	AM	DM	AM
45	DM	A	DM	DM	DM	DM	AM	A	DM	A	A	A
46	DM	AM	DM	DM	DM	MC	AP	DM	AM	DM	AM	DM
47	DM	AM	DM	DM	DM	DM	MC	DM	AM	DM	AM	DM
48	A	D	DM	AM	A	A	AM	A	DM	AM	DM	AM

	37	38	39	40	41	42	43	44	45	46	47	48
1	A	MC	AM	AM	DM	AM	A	AM	D	D	MC	D
2	DM	DM	DM	DM	A	DM	DM	DM	D	MC	AM	A
3	DM	DM	DM	DM	A	DM	D	DM	AM	A	AM	A
4	A	D	D	D	A	D	A	D	AP	A	AM	AM
5	MC	MC	MC	MC	A	MC	MC	MC	AM	AM	AP	A
6	D	D	A	D	D	D	A	MC	MC	MC	AM	MC
7	AP	MC	MC	MC	A	D	MC	MC	A	AM	AM	AM
8	A	AP	D	D	A	D	A	MC	A	AP	AM	AM
9	DM	MC	DM	DM	A	DM	DM	DM	A	AM	AM	AM
10	DM	DM	DM	DM	A	DM	D	D	DM	A	AM	DM
11	AM	AM	AM	AM	D	AM	AM	AM	DM	DM	DM	DM
12	DM	D	D	DM	A	DM	D	D	DP	A	AM	AM
13	DM	MC	MC	DM	A	DM	D	D	D	MC	AM	MC
14	A	MC	MC	A	MC	A	A	AM	D	MC	D	MC
15	AM	AM	A	AM	D	AM	AM	A	MC	D	D	A
16	A	A	A	A	MC	MC	A	MC	MC	MC	AM	MC
17	AM	AM	AM	AM	DM	AM	AM	AM	MC	MC	D	MC
18	A	A	A	A	D	A	A	A	MC	MC	D	D
19	AM	AM	D	A	A	MC	A	A	AM	AM	A	AM
20	AM	AM	MC	A	AM	MC	A	MC	MC	MC	A	A
21	AM	AM	AM	AM	DM	AM	AM	AM	DM	MC	DM	MC
22	AM	A	DM	A	AM	DM	A	DM	AM	AM	AM	AM
23	AM	AM	AM	AM	MC	A	A	A	MC	MC	MC	MC
24	A	A	A	A	D	A	A	A	MC	MC	DM	MC
25	A	A	A	AM	MC	A	A	AM	MC	MC	MC	MC
26	D	D	D	D	MC	D	MC	MC	MC	A	AM	MC
27	AM	AM	AM	AM	DM	AM	AM	AM	DM	DM	DM	DM
28	AM	AM	AM	AM	DM	AM	AM	AM	MC	MC	MC	MC
29	AM	A	A	A	DM	A	A	A	MC	MC	MC	MC
30	A	A	A	AM	DP	A	A	A	AP	MC	AP	AP
31	A	D	D	DM	AM	DM	DM	DM	AM	AM	AM	AM
32	AM	A	A	A	D	AM	AM	AM	DM	MC	D	AP
33	DM	DM	DM	DM	A	DM	DM	DM	MC	MC	AM	MC
34	AM	AM	AM	AM	MC	MC	A	AP	D	MC	D	MC
35	D	D	DP	DM	DP	D	D	DP	MC	AM	AM	MC
36	A	A	A	A	DM	A	A	A	MC	DM	DM	MC
37	AM	AM	AM	AM	DM	AM	AM	AM	DM	MC	DM	DM
38	A	AM	A	A	DM	A	A	AM	DM	MC	DM	DM
39	A	AM	AM	A	DM	AM	AM	AM	DM	DM	DM	DM
40	A	A	A	AM	DM	AM	A	A	DM	DM	DM	DM
41	D	D	DM	DM	AM	DM	DM	DM	AM	AM	AM	AM
42	AM	AM	AM	AM	DM	AM	AM	AM	DM	DM	DM	DM
43	AM	A	A	A	DM	A	AM	AM	DM	DM	DM	DM
44	AM	MC	A	AM	MC	A	A	AM	DM	DM	DM	DM
45	DM	DM	DM	DM	AM	DM	DM	DM	AM	AM	AM	AM
46	DM	DM	DM	DM	AM	DM	DM	DM	AM	AM	AM	AM
47	DM	DM	DM	DM	AP	DM	DM	DM	MC	AM	AM	AM
48	A	AP	DM	DM	AM	DM	DM	DM	AM	AM	AM	AM

Table B12 – Frequency of occurrence of expert #6's responses.

Expert Number: 6

Occurrence of Answers Concerning Activation Characteristics:

Concept	ACTIVATING NC	AM	A	AP	DM	D	DP	Concept	BEING ACTIVATED NC	AM	A	AP	DM	D	DP
1	18	9	11	4	1	5	0	1	7	9	16	0	9	6	1
2	4	6	12	3	14	9	0	2	6	6	8	4	11	13	0
3	6	12	8	0	17	5	0	3	3	8	10	1	14	11	1
4	10	10	13	3	3	9	0	4	4	8	7	5	10	12	2
5	29	6	6	6	1	0	0	5	6	7	7	5	9	11	3
6	11	5	10	3	5	12	2	6	7	2	11	8	8	9	3
7	13	9	13	5	4	4	0	7	12	3	9	7	6	6	5
8	5	13	14	5	2	9	0	8	16	3	9	6	5	4	5
9	5	13	6	4	17	3	0	9	14	9	8	3	6	4	4
10	2	6	8	1	24	7	0	10	10	4	5	11	7	4	7
11	0	17	9	1	17	4	0	11	2	8	18	0	12	8	0
12	5	4	16	6	8	8	1	12	6	14	2	2	17	7	0
13	7	5	11	1	18	6	0	13	8	9	5	2	9	15	0
14	10	13	10	0	11	4	0	14	7	8	15	3	12	2	1
15	4	14	14	0	2	13	1	15	4	9	24	0	10	1	0
16	32	1	14	0	0	1	0	16	22	8	15	0	2	1	0
17	13	13	13	0	7	2	0	17	2	17	17	1	9	2	0
18	12	9	15	0	1	11	0	18	3	12	20	1	6	6	0
19	13	14	17	0	2	2	0	19	11	9	10	6	5	7	0
20	17	10	18	0	2	1	0	20	6	11	18	5	4	4	0
21	9	14	11	2	7	5	0	21	0	13	23	1	4	7	0
22	4	14	18	0	4	8	0	22	13	10	6	3	11	5	0
23	7	15	11	1	4	9	1	23	1	21	15	1	8	2	0
24	10	10	15	1	11	1	0	24	23	6	11	1	7	0	0
25	8	11	15	1	9	4	0	25	9	13	17	1	5	3	0
26	6	8	12	1	10	9	2	26	9	10	8	1	13	7	0
27	2	23	2	1	20	0	0	27	6	14	11	0	11	6	0
28	5	23	3	0	15	1	1	28	3	14	16	1	12	2	0
29	5	13	14	0	16	0	0	29	3	18	10	2	12	3	0
30	3	11	15	3	14	1	1	30	4	19	10	2	12	1	0
31	2	13	17	2	6	8	0	31	14	9	2	2	14	5	2
32	4	13	11	6	2	12	0	32	3	18	18	1	6	2	0
33	7	2	7	4	18	10	0	33	2	8	4	2	21	11	0
34	7	14	10	1	5	10	1	34	1	27	9	1	8	2	0
35	8	8	4	5	9	11	3	35	2	9	5	2	25	5	0
36	3	10	16	0	10	9	0	36	1	26	10	0	9	2	0
37	5	10	15	1	7	10	0	37	1	17	15	1	10	4	0
38	7	9	14	1	8	2	7	38	7	14	11	2	7	7	0
39	4	13	12	1	8	2	8	39	5	11	14	0	11	6	1
40	0	11	15	0	11	4	7	40	2	15	13	0	14	4	0
41	2	11	9	14	7	5	0	41	7	7	12	1	13	6	2
42	0	19	7	0	18	4	0	42	5	12	11	0	14	6	0
43	1	13	11	0	12	8	3	43	3	11	20	0	9	5	0
44	5	17	9	0	14	2	1	44	7	15	9	1	11	4	1
45	4	12	7	6	17	2	0	45	16	9	3	2	12	5	1
46	4	18	2	1	23	0	0	46	20	12	5	1	8	2	0
47	4	12	1	5	26	0	0	47	5	21	2	2	12	6	0
48	2	20	8	4	13	1	0	48	16	13	5	2	10	2	0
Sum:	344	556	529	103	480	253	39	Sum:	344	556	529	103	480	253	39
% :	14.9	24.1	23.0	4.5	20.8	11.0	1.7	% :	14.9	24.1	23.0	4.5	20.8	11.0	1.7

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Table B13 – Expert #7's responses.

Expert Number: 7

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1	A	MC	MC	AM	MC	MC	MC	MC	MC	MC	A	MC	MC	A	A	MC	AM	AM	AP	A	A	MC	AM	MC	A	MC	AP	MC	AM	AM	MC	AM	MC	AM	MC	AM	AM	A	AM	AM	MC	AM	AM	AM	MC	MC	AP	MC
2	MC	AM	A	AM	AM	A	A	A	AM	A	MC	AM	AM	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	MC	AM	AP	MC	DM	DM	MC	MC	AM	DM	AM	MC	DM	DM	DM	DM	AP	DM	DM	DM	MC	A	AM	DM
3	MC	AM	AM	AM	AM	A	AP	AP	AP	AM	MC	AM	AM	MC	MC	AM	MC	MC	MC	MC	MC	A	MC	MC	MC	AM	A	DM	DM	DM	DM	D	A	DM	AM	MC	D	DM	DM	DM	AM	D	MC	MC	MC	A	AM	MC
4	MC	AM	D	AM	AM	D	D	AP	AM	MC	AP	AM	AM	DM	A	MC	A	MC	A	A	A	AM	A	MC	A	AM	A	A	A	D	MC	A	D	AM	DM	AM	AM	AM	D	DM	AM	D	D	MC	A	A	AM	AM
5	MC	A	A	AM	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	AP	MC	MC	MC	A	MC	MC	MC	MC	MC	MC	DM	AM	AM	MC	MC	MC	MC	MC	MC	DM	MC	DM	MC	A	AM	MC
6	MC	AM	AM	AM	A	AM	MC	MC	AM	AM	MC	AM	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	DM	DM	DM	DM	DM	DM	AM	DM	AM	DM	DM	DM	DM	MC	MC	DM	MC	MC	MC	AM	AM	DM
7	MC	AM	AM	AM	AM	AM	AM	AM	A	A	MC	AM	MC	MC	AM	MC	AM	A	AM	AM	A	AM	AM	MC	AM	AM	AM	AM	DM	DM	AM	A	D	A	D	AM	A	A	DM	AM	AM	DM	DM	MC	MC	MC	AM	MC
8	MC	AM	A	AM	A	DM	AM	AM	AM	DM	DM	AM	MC	MC	A	MC	A	A	AM	AM	A	A	A	MC	A	AM	A	AM	DM	DM	AM	DM	DM	A	DM	A	A	A	MC	MC	AM	DM	DM	DM	MC	MC	AM	AM
9	MC	AM	A	AM	AM	MC	MC	MC	AM	A	MC	AM	AM	MC	MC	A	MC	A	MC	MC	MC	A	DM	MC	MC	A	MC	MC	DM	DM	MC	DM	AM	DM	AM	A	MC	MC	MC	DM	AM	DM	DM	DM	MC	A	AM	MC
10	MC	AM	A	AM	AM	A	MC	MC	A	AM	MC	AM	AM	MC	MC	MC	DM	A	DM	DM	MC	MC	A	MC	MC	AM	AM	AM	DM	DM	DM	DM	AM	DM	A	D	DM	DM	DM	DM	DM	DM	DM	DM	MC	AM	AM	DM
11	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	A	A	MC	A	A	MC	MC	A	MC	AM	MC	AM	MC	AM	A	AM	AM	MC	AM	MC	A	MC	A	A	MC	AM	AM	MC	MC	A	A	MC	MC	MC	MC
12	MC	AM	AP	AM	A	A	AM	A	AM	AM	MC	AM	A	MC	A	AM	DM	DM	DM	DM	DM	A	DM	DM	DM	AM	A	DM	DM	DM	MC	DM	AM	DM	AM	DM	DM	DM	DM	DM	A	DM	DM	MC	MC	A	AM	DM
13	MC	AM	AM	A	A	A	A	A	A	A	D	A	AM	DM	DM	D	DM	MC	DM	DM	MC	MC	D	D	MC	A	D	MC	D	DM	DM	D	AM	DM	AP	D	D	A	MC	MC	AP	MC	MC	MC	DM	AP	A	DM
14	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AM	AM	AM	AM	AM	AM	AM	AM	MC	AM	AM	AM	MC	AM	AM	AM	AM	A	AM	MC	AM	MC	AM	A	A	AM	AM	A	AP	A	AM	A	MC	A	AM
15	A	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	AM	AM	AM	AM	AM	A	A	A	MC	AM	AM	AM	MC	AM	AM	AM	AM	AP	AM	DM	AM	DM	AM	A	A	A	AM	A	D	AM	A	A	MC	AM	AM
16	A	DM	DM	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	AM	AM	AM	AM	A	A	A	AM	MC	AM	DM	AM	MC	AM	AM	AM	AM	MC	AM	MC	AM	MC	AM	A	AP	AP	A	AM	D	A	A	A	A	AM	AM
17	AM	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AM	MC	AM	AM	AM	AM	AM	AM	AM	AM	A	AM	MC	AM	AM	AM	AM	A	A	DM	AM	DM	AM	DM	AM	A	A	A	AM	A	A	AM	AM	AM	AM	AM	AM
18	A	MC	AP	MC	MC	MC	MC	MC	MC	MC	AP	MC	MC	A	A	A	A	AM	MC	A	A	MC	A	A	A	MC	A	A	A	A	MC	A	DM	A	DM	A	A	A	A	MC	DM	A	A	A	DM	DM	AP	MC
19	MC	MC	MC	MC	MC	MC	AM	AM	MC	MC	MC	MC	MC	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	DM	AM	AM	MC	AM	AM	AM	AM	AM	DM	AM	DM	AM	AM	AM	DM	AM	AM	DM	DM	MC	AM	A	AM	AM
20	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	AM	AM	AM	AM	AM	AM	AM	MC	AM	AP	AM	MC	AM	AM	AM	DM	A	A	DM	AM	DM	AM	AM	AM	AM	AM	A	DM	DM	A	A	MC	AM	AM
21	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	DM	AM	AM	AM	AM	AM	AM	A	A	MC	A	A	A	MC	A	A	AM	AM	AP	A	DM	AM	MC	A	A	A	A	A	MC	A	A	A	MC	MC	A	AP
22	AP	MC	MC	AM	DM	DM	AM	AM	AM	MC	MC	AM	MC	A	AM	AM	AM	AP	AM	AP	D	AM	AM	DM	AM	AM	AM	AM	DM	DM	AM	A	DM	AM	DM	AM	AM	A	DM	AM	AM	DM	A	A	AM	AM	AM	AM
23	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AM	AM	AM	AM	AM	A	A	AM	AP	AM	A	AM	AP	AM	AM	AM	AM	DM	AM	DM	AM	DM	AM	AM	AM	AM	AM	MC	AM	AM	AM	MC	MC	AP	AP
24	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AP	MC	MC	AM	AM	AM	AM	AM	AP	DM	AM	MC	AM	AM	AM	MC	A	A	AM	AM	MC	AM	MC	AM	MC	AM	AM	AM	AM	AM	MC	AM	AM	AM	MC	MC	MC	DM
25	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	A	A	A	AM	AM	A	AP	A	MC	A	MC	AM	MC	A	A	AM	AM	MC	AM	DM	AM	MC	AM	AM	AM	AM	AM	MC	AM	AM	AM	MC	MC	MC	MC
26	MC	AM	AM	AM	AM	AM	MC	MC	AM	AM	MC	AM	AM	DM	AM	AM	DM	AM	DM	MC	MC	AP	DM	DM	DM	AM	MC	MC	DM	DM	DM	MC	A	DM	AM	DM	DM	DM	DM	DM	MC	DM	DM	DM	MC	AM	AM	MC
27	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	DM	AM	AM	AM	AM	AM	AP	AP	AM	MC	AM	A	AM	DM	AM	AM	AM	AM	DM	AM	DM	AM	MC	AM	AM	AM	AM	AM	DM	AM	AM	AM	MC	MC	MC	MC
28	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AM	AM	AM	AM	AM	AP	AP	AM	AP	AM	A	AM	MC	MC	AM	AM	AM	AP	AM	DM	AM	DM	AM	AM	AM	AM	AM	DM	AM	AM	AM	AP	DM	AP	AP
29	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AM	AM	AM	AM	AM	AP	AP	AM	MC	AM	AM	AM	MC	MC	A	AM	AM	DM	AM	DM	AM	DM	AM	AM	AM	AM	AM	DM	AM	AM	AM	DM	MC	DM	DM
30	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AM	AM	AM	AM	AM	AP	AP	AM	DM	AM	AP	A	MC	AM	AM	AM	AM	DM	AM	DM	AM	DM	AM	AM	AM	AM	AM	DM	AM	AM	AM	DM	DM	DM	DM
31	MC	MC	MC	A	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	A	AM	AM	DM	AM	AM	A	AM	A	MC	A	A	A	AM	AM	DP	AM	A	DM	A	DM	A	AP	AP	DM	A	AM	DM	DM	DM	AM	A	AM	A
32	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	A	AM	AM	AM	AP	AP	AM	MC	AM	MC	AM	MC	AM	AM	AM	AM	MC	AM	MC	AM	MC	AM	AM	AM	AM	AM	AP	AM	AM	AM	MC	MC	A	AM
33	MC	AM	A	A	AP	A	MC	MC	A	A	MC	A	AP	DM	DM	DM	DM	DM	DM	DM	DM	MC	MC	MC	MC	A	A	DM	DM	DM	DM	DM	AM	DM	AM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	AM	A	MC
34	AM	MC	D	MC	MC	MC	MC	MC	MC	MC	A	DM	MC	AM	AM	AM	AM	AM	A	A	AM	MC	AM	A	AM	DM	AM	AM	AM	AM	DM	AM	DM	AM	DM	AM	AM	AM	AM	AM	DM	AM	AM	AM	AP	DM	AM	AM
35	MC	A	AM	A	A	AM	MC	AP	AM	AM	MC	AM	A	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	MC	AM	A	MC	DM	DM	DM	DM	AM	MC	AM	DM	DM	DM	DM	DM	A	DM	DM	DM	DM	AM	AM	DM
36	AM	MC	MC	MC	MC	DM	MC	MC	DM	MC	AM	DM	DM	AM	AM	AM	AM	AM	A	AP	AM	DM	AM	A	AM	DM	AM	AM	AM	AM	DM	AM	DM	AM	DM	AM	AM	AM	AM	AM	DM	AM	AM	AM	AP	DM	DM	A
37	A	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	A	A	A	AM	AM	A	A	AM	MC	AM	A	AM	MC	AM	AM	AM	AM	MC	AM	MC	AM	MC	AM	AM	AM	AM	AM	DM	AM	AM	AM	D	MC	MC	A
38	A	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	A	AM	A	A	A	AP	MC	AP	MC	A	A	A	MC	DM	A	AM	AM	MC	AM	DM	AM	MC	AM	AM	AM	AM	AM	DM	AM	AM	AM	DM	MC	AP	DM
39	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	AM	A	A	AM	AM	MC	AP	A	MC	AM	AM	AP	MC	A	A	AM	AM	MC	AM	MC	AM	DM	AM	AM	AM	AM	AM	DM	AM	AM	AM	DM	DM	DM	DM
40	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AM	AM	AM	AM	AM	AP	A	A	MC	AM	A	AM	DM	AM	AM	AM	AM	DM	AM	DM	AM	DM	AM	AM	AM	AM	AM	DM	AM	AM	AM	MC	MC	MC	A
41	MC	MC	AP	MC	A	MC	A	AP	MC	MC	MC	A	A	D	A	AP	A	DM	A	AP	MC	AP	AP	D	A	AM	DM	DM	D	DM	AM	D	A	DM	AP	DM	D	D	D	D	AM	DM	D	DM	AM	A	AM	AM
42	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AM	AM	AM	AM	AM	A	A	AM	MC	AM	AM	AM	MC	AM	AM	AM	AM	DM	AM	DM	AM	DM	AM	AM	AM	AM	AM	DM	AM	AM	AM	DM	DM	A	A
43	A	AP	A	MC	MC	MC	MC	MC	AP	MC	A	AP	MC	A	A	AM	AM	AM	A	A	A	MC	AM	A	AM	MC	A	A	A	A	MC	A	DM	AM	AP	A	AM	AM	AM	AM	AP	AM	AM	AM	AP	AP	A	AM
44	AM	MC	MC	MC	MC	MC	AP	AP	MC	MC	A	MC	MC	AM	AM	AM	AM	AM	AM	AM	A	MC	AM	AP	AM	MC	AM	AM	AM	AM	A	A	DM	AM	MC	AM	AM	AM	AM	AM	AP	AM	AM	AM	AP	MC	AM	AM
45	AP	MC	A	MC	MC	MC	MC	A	A	MC	D	A	DM	A	AM	A	A	AP	AM	AM	A	A	A	DM	A	A	AM	AM	D	D	A	AM	DM	AM	MC	AP	A	MC	DM	AP	A	DM	AP	AP	AM	AP	AM	AM
46	MC	AM	AM	AM	AM	AM	AM	AM	AM	AM	DM	AM	AM	DM	A	AM	DM	DM	DM	DM	DM	AM	DM	DM	AM	AM	AM	AM	DM	DM	DM	DM	AM	DM	AM	DM	DM	DM	DM	DM	AM	DM	DM	DM	AM	AM	AM	D
47	MC	AM	AM	AM	AM	AM	AM	A	A	A	MC	AM	A	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	DM	MC	A	A	MC	DM	DM	A	DM	AM	DM	A	DM	DM	DM	DM	DM	AM	DM	DM	DM	AM	AM	AM	DM
48	AM	DM	AP	MC	MC	MC	AP	AP	AP	MC	MC	MC	DM	AM	AM	AM	AM	A	A	AM	AM	MC	AM	MC	AM	MC	AM	AM	AM	AM	AP	AM	DM	AM	DM	AM	AM	AM	AM	AM	DM	AM	AM	AM	DM	DM	AM	AM

Table B14 – Frequency of occurrence of expert #7's responses.

Expert Number: 7

Occurrence of Answers Concerning Activation Characteristics:

Concept	A C T I V A T I N G						
	NC	AM	A	AP	DM	D	DP
1	22	15	8	3	0	0	0
2	18	10	7	2	11	0	0
3	17	12	5	3	8	3	0
4	7	15	13	2	3	8	0
5	35	5	4	1	3	0	0
6	21	13	1	0	13	0	0
7	10	23	8	0	5	2	0
8	9	14	14	0	11	0	0
9	21	10	8	0	9	0	0
10	12	12	6	0	17	1	0
11	27	10	11	0	0	0	0
12	6	11	9	1	21	0	0
13	11	4	11	3	10	9	0
14	16	24	7	1	0	0	0
15	14	19	11	1	2	1	0
16	14	18	10	2	3	1	0
17	11	26	8	0	3	0	0
18	16	1	23	3	5	0	0
19	13	28	1	0	6	0	0
20	15	22	5	1	5	0	0
21	16	9	19	2	2	0	0
22	5	25	5	3	9	1	0
23	14	24	3	4	3	0	0
24	20	22	2	2	2	0	0
25	21	16	9	1	1	0	0
26	12	16	1	1	18	0	0
27	16	24	1	2	5	0	0
28	13	23	1	7	4	0	0
29	15	23	1	2	7	0	0
30	12	23	1	3	9	0	0
31	13	11	14	2	7	0	1
32	20	22	3	3	0	0	0
33	9	4	9	2	24	0	0
34	10	25	4	1	7	1	0
35	16	10	7	1	14	0	0
36	7	24	3	2	12	0	0
37	18	20	8	0	1	1	0
38	17	13	10	3	5	0	0
39	16	18	6	2	6	0	0
40	15	23	4	1	5	0	0
41	8	6	10	7	8	9	0
42	13	25	4	0	6	0	0
43	10	14	16	7	1	0	0
44	13	25	4	5	1	0	0
45	8	10	15	7	5	3	0
46	1	23	1	0	22	1	0
47	14	12	8	0	14	0	0
48	9	25	2	5	7	0	0
Sum:	676	807	341	98	340	41	1
% :	29.3	35.0	14.8	4.3	14.8	1.8	.0

Concept	B E I N G A C T I V A T E D						
	NC	AM	A	AP	DM	D	DP
1	19	20	7	2	0	0	0
2	29	14	2	1	2	0	0
3	25	8	8	4	1	2	0
4	29	15	4	0	0	0	0
5	30	10	6	1	1	0	0
6	32	6	6	0	3	1	0
7	34	7	3	3	0	1	0
8	32	5	5	6	0	0	0
9	27	11	6	3	1	0	0
10	34	7	6	0	1	0	0
11	21	11	9	3	2	2	0
12	25	16	4	1	2	0	0
13	29	9	4	1	5	0	0
14	11	20	11	0	5	1	0
15	8	24	14	0	2	0	0
16	11	27	7	1	1	1	0
17	7	28	7	0	6	0	0
18	8	25	8	2	5	0	0
19	10	10	13	9	6	0	0
20	10	10	12	10	6	0	0
21	11	17	15	1	3	1	0
22	27	6	8	5	2	0	0
23	7	26	9	1	4	1	0
24	18	6	11	3	8	2	0
25	10	25	10	1	2	0	0
26	21	15	7	1	4	0	0
27	6	22	14	2	3	1	0
28	8	25	10	0	5	0	0
29	1	26	4	0	14	3	0
30	1	24	3	0	17	2	1
31	16	6	5	4	17	0	0
32	3	24	9	0	9	3	0
33	8	10	3	0	25	2	0
34	1	30	5	0	12	0	0
35	13	10	2	3	19	1	0
36	3	27	7	1	8	2	0
37	2	23	10	1	9	3	0
38	4	21	10	2	10	1	0
39	4	22	4	1	15	2	0
40	5	27	3	1	11	1	0
41	9	12	7	5	15	0	0
42	2	19	3	1	19	4	0
43	4	21	6	1	14	2	0
44	7	21	7	1	12	0	0
45	19	8	5	5	10	1	0
46	18	9	10	3	8	0	0
47	6	26	7	5	4	0	0
48	11	16	5	3	12	1	0
Sum:	676	807	341	98	340	41	1
% :	29.3	35.0	14.8	4.3	14.8	1.8	.0

Table B15 – Expert #8's responses.

Expert Number : 8

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1	A	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	A	MC	MC	A	A	MC	MC	A	MC	A	A	MC	MC	MC	MC	A	A	MC	A	D	A	D	A	A	MC	A	A	DM	A	A	A	MC	MC	MC	MC
2	MC	A	A	A	MC	A	MC	MC	AM	MC	MC	AM	AM	MC	MC	MC	MC	MC	A	A	MC	MC	MC	DM	A	A	MC	MC	MC	MC	MC	DM	A	D	A	DM	D	A	A	MC	D	A	A	MC	MC	A	A	MC
3	MC	A	A	AM	A	A	A	A	A	A	MC	A	A	MC	A	MC	A	MC	A	A	D	A	D	MC	A	AM	DM	D	D	D	D	MC	A	D	AM	D	A	A	A	D	D	A	MC	MC	A	A	A	A
4	MC	A	MC	A	A	A	A	A	A	A	MC	A	MC	MC	A	MC	A	MC	AM	A	MC	AM	A	MC	A	AM	MC	MC	MC	MC	A	A	D	A	MC	MC	A	A	A	MC	D	A	A	MC	AM	AM	AM	AM
5	MC	MC	A	A	A	A	MC	MC	A	A	MC	A	A	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	D	A	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	A	A	A
6	MC	A	A	A	A	A	A	MC	A	A	DM	A	A	DM	MC	MC	DP	MC	MC	MC	MC	MC	A	MC	MC	MC	A	A	DM	DM	DM	D	A	A	A	D	D	D	D	MC	A	D	D	MC	MC	D	AM	D
7	MC	A	A	A	MC	A	A	MC	A	A	MC	A	A	D	MC	MC	MC	MC	A	A	MC	A	A	MC	A	A	MC	MC	MC	MC	MC	MC	A	A	D	A	A	D	D	MC	A	D	D	DM	A	A	AM	AM
8	MC	A	AM	A	A	A	A	A	AM	A	DM	A	A	MC	A	MC	D	D	A	AM	D	AM	A	MC	MC	AM	DM	DM	DM	DM	MC	A	D	A	D	A	D	D	D	D	A	D	D	D	A	A	AM	AM
9	MC	AM	A	A	A	A	A	A	A	MC	D	A	A	D	A	MC	D	D	D	A	D	AM	A	D	AM	A	A	A	D	D	A	D	A	D	A	D	D	D	D	D	A	D	D	MC	A	A	AM	DM
10	MC	AM	A	A	A	A	A	MC	A	A	MC	A	A	MC	A	MC	A	MC	A	D	D	A	A	MC	AM	A	AM	AM	D	D	MC	MC	D	D	A	D	D	D	D	D	A	D	D	MC	D	A	A	D
11	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	MC	MC	MC	MC	MC	A	A	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	A	MC	A	MC	MC	MC	MC
12	MC	AM	A	A	A	MC	A	A	AM	A	DM	A	A	D	A	MC	D	D	A	A	D	A	D	AM	A	A	DM	D	D	D	D	MC	A	D	A	A	D	D	D	D	A	D	D	MC	A	A	A	D
13	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	MC	MC	MC	A	A	MC	MC	MC	AP	MC	MC	MC	A	A	A	A	A	D	A	MC	MC	MC	MC	D	MC	A	D	MC	D	A	MC	A	MC
14	A	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	A	MC	MC	A	A	A	A	A	MC	A	A	MC	MC	A	A	MC	MC	MC	MC	MC	A	MC	A	A	MC	A	A	MC	MC	A	A	D	MC	A	MC
15	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	A	D	A	MC	A	MC	A	MC	A	MC	MC	MC	MC	MC	MC	A	D	A	MC	MC	A	MC	MC	A	A	D	MC	MC	MC	MC	MC	A
16	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	A	MC	MC	MC	MC	MC	A	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	A	A	A	MC	A	MC	A	MC	A	MC	AM	MC
17	MC	MC	D	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	A	MC	A	A	A	MC	A	MC	MC	MC	MC	A	A	A	MC	A	DM	AM	MC	A	A	A	A	MC	MC	A	A	A	A	MC	A	A
18	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	D	MC	MC	A	MC	MC	MC	MC	MC	A	MC	MC	A	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	A	D	A	A	A	MC	MC	MC	MC
19	MC	MC	MC	A	MC	MC	A	A	A	MC	MC	A	MC	MC	A	MC	A	A	A	A	MC	MC	A	MC	MC	A	A	A	A	A	A	A	MC	A	MC	A	A	MC	D	MC	A	D	A	D	A	A	A	A
20	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	A	A	A	A	A	MC	A	MC	MC	MC	MC	A	MC	MC	A	MC	D	A	MC	A	MC	MC	D	MC	A	D	AP	AP	AP	MC	A	AM
21	AP	AP	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	AP	A	A	MC	A	MC	AP	MC	AP	MC	MC	MC	MC	MC	MC	AP	MC	A	MC	A	AP	MC	MC	AP	A	D	A	A	MC	MC	A	A
22	MC	DM	DM	AM	A	A	MC	MC	A	MC	MC	A	A	MC	MC	MC	MC	MC	A	MC	A	A	A	MC	MC	MC	MC	A	AP	AP	A	A	D	A	MC	A	A	MC	MC	A	A	D	A	MC	A	A	AM	A
23	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	MC	A	MC	MC	MC	A	MC	MC	A	AP	AP	MC	A	D	AM	MC	A	A	MC	MC	AP	AP	MC	MC	AM	MC	MC	DM	A
24	AM	DM	MC	MC	MC	MC	MC	MC	MC	MC	MC	DM	MC	AP	MC	MC	MC	AM	DM	MC	MC	MC	MC	A	MC	MC	AP	AP	MC	MC	MC	MC	D	MC	MC	MC	MC	MC	A	AM	DM	A	MC	AP	MC	MC	DM	D
25	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	A	A	MC	A	MC	A	MC	A	A	AM	AM	MC	A	D	A	MC	A	AP	MC	MC	AM	AP	MC	A	AM	MC	MC	A	A
26	MC	A	AM	AM	A	MC	MC	MC	AM	AP	MC	A	A	D	MC	MC	D	D	A	MC	MC	A	A	A	MC	A	AM	AM	D	D	MC	MC	MC	D	A	A	D	MC	MC	MC	AM	D	D	MC	MC	MC	AM	MC
27	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	A	MC	MC	A	AM	DM	A	A	MC	A	AP	A	AM	A	AM	AM	AM	AP	AP	MC	A	MC	A	MC	MC	A	AM	DM	AM	A	AM	DM	MC	DM	DM
28	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	A	AP	A	MC	MC	A	AP	AM	MC	AM	A	AM	AM	AP	A	DM	A	MC	A	MC	MC	A	A	DM	A	A	A	DM	D	MC	A
29	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AP	MC	MC	MC	A	MC	A	A	DM	MC	MC	MC	MC	AP	AP	MC	AM	AM	A	A	AP	AP	DM	A	MC	AP	MC	MC	A	A	DM	A	A	AM	DM	D	DM	D
30	AP	MC	DM	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	A	MC	MC	MC	MC	MC	MC	MC	DM	MC	A	A	A	A	MC	A	DM	A	MC	MC	MC	MC	A	A	MC	MC	MC	A	MC	MC	MC	DM
31	AP	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	A	MC	A	MC	AM	AM	MC	MC	A	MC	A	MC	A	A	AM	AM	A	A	MC	A	MC	MC	MC	MC	MC	MC	AM	DM	MC	DM	AM	AP	A	A
32	A	DM	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	A	MC	A	MC	MC	MC	MC	MC	A	MC	MC	MC	MC	A	A	A	MC	A	MC	A	MC	A	A	MC	A	A	MC	MC	A	A	MC	MC	A	A
33	MC	A	A	A	MC	A	MC	MC	MC	MC	MC	AP	MC	MC	MC	MC	DM	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	D	D	MC	MC	A	D	A	MC	MC	MC	MC	MC	A	MC	MC	DM	MC	MC	A	MC
34	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	D	A	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC
35	MC	AP	A	A	A	A	MC	MC	A	A	MC	A	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	MC	A	A	MC	D	D	DM	MC	A	DM	A	MC	MC	MC	MC	MC	A	D	D	D	D	MC	AM	MC
36	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	AP	MC	MC	MC	MC	MC	AP	MC	MC	MC	MC	MC	MC	MC	MC	AP	MC	A	MC	A	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	MC	MC
37	AP	MC	DM	MC	MC	MC	MC	MC	MC	MC	MC	DP	MC	MC	MC	MC	A	MC	MC	MC	MC	MC	A	MC	A	MC	A	A	MC	A	A	A	D	A	MC	A	A	AP	A	A	MC	A	AP	A	MC	MC	AP	AP
38	A	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	AP	A	MC	A	MC	MC	MC	AP	MC	MC	A	MC
39	A	D	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	A	MC	MC	MC	MC	AP	MC	A	MC	A	A	A	MC	MC	MC	MC	A	MC	AP	A	MC	A	A	MC	A	A	A	MC	MC	AP	MC
40	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	MC	MC	MC	MC	MC	MC	DM	MC	MC	MC	MC	MC	AP	A	MC	MC	MC	AP	MC	MC	MC	MC
41	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	DM	DM	DM	A	MC	A	A
42	A	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	MC	MC	MC	DM	A	MC	AP	MC	MC	AM	A	MC	A	A	A	MC	MC	MC	MC
43	A	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	MC	MC	MC	A	MC	AP	MC	A	A	AP	A	MC	AM	MC	A	MC	A	MC	MC	A	A	MC	MC	A	AM	MC	MC	A	MC
44	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	MC	MC	MC	MC	MC	A	MC	A	A	AM	AM	MC	A	MC	A	MC	A	A	MC	A	AM	MC	A	A	A	MC	MC	DM	MC
45	MC	A	A	A	MC	MC	MC	MC	A	MC	MC	A	MC	MC	A	MC	MC	AP	AM	A	MC	MC	A	MC	MC	A	MC	MC	MC	MC	AM	MC	MC	A	MC	A	A	MC	DM	D	A	D	D	DM	DM	MC	A	MC
46	MC	A	A	AM	A	A	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	A	A	AM	A	AM	MC	MC	MC	MC	A	D	AM	D	MC	MC	D	MC	A	D	D	D	MC	A	A	MC
47	MC	A	AP	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	MC	MC	MC	MC	MC	MC	MC	MC	AM	DM	MC	MC	MC	MC	MC	DM	MC	D	DM	MC	MC	MC	A	MC
48	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	A	A	A	MC	A	A	MC	A	MC	A	A	AP	AP	AP	A	DM	A	MC	MC	A	MC	DM	A	A	D	D	A	A	MC	A	A

Table B16 – Frequency of occurrence of expert #8's responses.

Expert Number: 8

Occurrence of Answers Concerning Activation Characteristics:

Concept	A C T I V A T I N G							Concept	B E I N G A C T I V A T E D						
	NC	AM	A	AP	DM	D	DP		NC	AM	A	AP	DM	D	DP
1	26	0	19	0	1	2	0	1	30	7	7	4	0	0	0
2	23	3	16	0	3	3	0	2	28	3	11	2	3	1	0
3	9	3	25	0	1	10	0	3	29	2	12	1	3	1	0
4	17	7	22	0	0	2	0	4	31	4	13	0	0	0	0
5	33	1	13	0	0	1	0	5	36	0	12	0	0	0	0
6	15	1	17	0	5	9	1	6	35	0	13	0	0	0	0
7	17	2	22	0	1	6	0	7	39	0	9	0	0	0	0
8	6	7	18	0	5	12	0	8	42	0	6	0	0	0	0
9	4	4	21	0	1	18	0	9	33	4	11	0	0	0	0
10	10	4	19	0	0	15	0	10	38	0	9	1	0	0	0
11	41	0	7	0	0	0	0	11	40	0	3	1	3	1	0
12	5	3	21	0	2	17	0	12	29	1	15	1	1	0	1
13	31	0	12	1	0	4	0	13	33	3	12	0	0	0	0
14	27	0	20	0	0	1	0	14	37	0	5	1	1	4	0
15	33	0	12	0	0	3	0	15	33	0	14	0	0	1	0
16	37	1	10	0	0	0	0	16	47	0	1	0	0	0	0
17	25	1	20	0	1	1	0	17	17	0	23	2	1	4	1
18	37	0	9	0	0	2	0	18	29	2	11	1	0	5	0
19	18	0	27	0	0	3	0	19	24	3	16	1	3	1	0
20	28	1	13	3	0	3	0	20	29	2	16	0	0	1	0
21	29	0	10	8	0	1	0	21	32	0	11	0	0	5	0
22	19	2	21	2	2	2	0	22	36	4	8	0	0	0	0
23	32	2	8	4	1	1	0	23	19	0	24	3	0	2	0
24	31	3	3	4	5	2	0	24	33	1	8	4	1	1	0
25	27	5	13	2	0	1	0	25	26	3	15	3	1	0	0
26	20	7	11	1	0	9	0	26	34	5	9	0	0	0	0
27	19	9	12	3	5	0	0	27	23	4	17	1	3	0	0
28	22	5	14	3	3	1	0	28	20	5	19	1	1	2	0
29	21	4	10	6	5	2	0	29	21	5	9	4	2	7	0
30	32	0	11	1	4	0	0	30	21	5	10	3	2	7	0
31	26	7	11	2	2	0	0	31	31	1	8	4	2	2	0
32	29	0	18	0	1	0	0	32	23	1	17	4	1	2	0
33	34	0	8	1	2	3	0	33	17	1	9	0	7	14	0
34	46	0	1	0	0	1	0	34	6	2	30	0	2	8	0
35	25	1	13	1	2	6	0	35	34	3	8	0	0	3	0
36	42	0	3	3	0	0	0	36	18	0	21	3	1	5	0
37	25	0	15	5	1	1	1	37	21	0	17	3	0	7	0
38	42	0	4	2	0	0	0	38	35	0	6	1	0	6	0
39	30	0	14	3	0	1	0	39	16	1	18	1	2	10	0
40	42	1	2	2	1	0	0	40	18	4	17	2	1	6	0
41	40	1	4	0	3	0	0	41	16	2	19	2	5	4	0
42	37	1	8	1	1	0	0	42	13	1	14	0	2	18	0
43	32	2	12	2	0	0	0	43	14	0	19	2	2	11	0
44	31	4	12	0	1	0	0	44	14	5	15	4	5	5	0
45	25	2	14	1	3	3	0	45	25	2	13	1	4	3	0
46	26	5	11	0	0	6	0	46	32	1	11	1	0	3	0
47	39	1	3	1	3	1	0	47	10	9	22	2	5	0	0
48	23	0	18	3	2	2	0	48	21	4	14	1	3	5	0
Sum:	1288	100	627	65	67	155	2	Sum:	1288	100	627	65	67	155	2
% :	55.9	4.3	27.2	2.8	2.9	6.7	.1	% :	55.9	4.3	27.2	2.8	2.9	6.7	.1

Table B17 – Expert #9's responses.

Expert Number: 9

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1	AM	AP	MC	MC	MC	D	AM	AM	MC	DP	AM	MC	D	AM	A	A	A	DM	MC	A	A	MC	AM	AM	DP	MC	A	A	A	A	D	AM	D	A	D	A	A	A	A	A	D	A	A	AM	D	D	D	DM
2	MC	AM	AM	AM	AM	AM	AM	AM	AM	AP	AP	AM	AM	D	DM	D	D	D	D	AM	AP	A	D	D	DM	AP	DM	DM	DM	D	DP	D	D	D	AP	AP	D	D	D	D	D	D	D	DM	MC	A	A	DM
3	MC	AM	AM	AM	AM	A	A	A	A	A	DM	AM	AM	D	D	D	D	A	D	AP	AP	A	D	D	AP	AP	D	D	D	D	DP	D	AM	D	AM	DM	DM	D	D	D	AM	D	DM	D	A	A	A	A
4	MC	AM	AM	AM	AM	AP	A	A	A	A	D	AM	AM	D	D	D	D	D	AP	AP	DM	AP	D	D	AP	AP	D	D	D	D	AP	D	DM	A	DP	D	AP	DP	DP	DP	A	D	D	DP	AM	A	A	A
5	MC	A	A	A	AM	AP	AP	AP	AP	AP	MC	A	A	D	D	D	D	D	D	A	D	AP	D	D	D	A	A	D	D	D	A	D	A	D	A	D	D	D	D	D	A	D	D	D	A	A	A	A
6	MC	A	A	A	A	AM	AP	AP	AP	AP	D	D	A	D	D	D	D	D	AP	AP	D	AP	D	D	D	AP	D	D	D	D	AP	D	A	D	A	D	D	D	D	DM	DM	DM	DM	DM	AP	AP	AP	AP
7	DM	AP	AP	AP	AP	AP	AP	AP	AP	AP	D	A	A	D	D	D	DM	D	AM	AM	AM	AM	D	DM	AP	A	D	D	D	D	A	DM	A	D	AM	D	D	DM	DM	DM	DM	DM	DM	DM	AM	A	A	A
8	MC	AM	AP	AM	A	AP	AP	AM	A	AP	D	A	A	D	D	D	D	D	A	A	AP	D	D	D	AP	AP	D	D	D	D	AP	D	AP	D	AP	D	DP	D	DM	D	AM	DM	DM	D	A	AP	AM	A
9	MC	AM	A	A	AP	AP	AP	AP	AM	AP	D	AM	A	D	D	D	D	D	DP	AP	DM	AP	DM	D	D	D	D	D	D	DM	DP	D	AM	DM	A	D	D	DM	D	DM	A	D	D	DM	A	A	A	A
10	MC	A	A	A	A	A	A	A	AP	AM	D	A	A	D	D	D	DM	DM	AP	AP	D	AP	D	D	D	D	D	DM	DM	D	D	D	A	D	A	D	D	D	DM	DM	AP	D	D	DM	AP	AP	AP	AP
11	AM	DM	DM	DM	DM	DM	DM	DM	DM	DM	AM	D	D	A	AM	AM	AM	AM	DP	D	AP	D	A	AM	A	D	AM	AM	AM	AM	DM	AM	D	AM	D	AM	AM	AM	AM	AM	D	AM	AM	AM	D	D	D	D
12	MC	AM	A	A	A	A	A	A	A	A	D	AM	AM	DM	D	D	D	D	A	A	AP	AP	AP	D	AP	AP	D	DM	DM	DM	MC	D	AM	DM	A	DM	DM	DM	DM	DM	AP	DM	D	D	D	AP	AP	AP
13	DM	AP	AP	AP	AP	AP	AP	AP	AP	AP	D	AP	AP	MC	D	D	D	D	DP	D	D	AP	DP	DP	D	AP	D	D	D	MC	MC	D	AP	D	DP	DP	DM	D	DP	DP	AP	D	D	D	AP	AP	AP	AP
14	AM	D	D	D	D	D	D	D	D	DM	AP	MC	MC	AM	A	A	A	A	D	AP	A	D	A	A	A	D	AM	AM	AM	AM	AP	AM	D	AM	D	AM	A	A	A	A	AM	MC	AM	AM	AP	MC	D	D
15	AM	MC	AP	MC	MC	D	D	D	MC	D	A	D	D	A	AM	AM	AM	A	AP	A	AM	MC	AM	AM	AP	D	A	AM	AM	AM	AP	AM	D	AM	D	AM	AM	AM	AP	A	AP	A	A	A	AP	MC	AP	AP
16	AP	D	D	D	D	D	D	D	D	MC	A	D	D	A	A	A	A	AP	D	AP	AM	MC	A	AP	A	D	AP	AM	AP	AP	AP	AM	D	A	D	AM	AM	AP	A	A	AP	A	A	A	AP	MC	AM	AM
17	AM	DM	A	AP	MC	AP	AP	MC	MC	D	AP	D	D	A	AM	AM	AM	AM	AP	AP	AP	MC	AM	AP	AP	DP	A	AM	AM	AM	AP	AM	DM	AM	DM	AM	AM	AM	AM	AM	AP	A	A	A	AP	MC	AM	A
18	A	D	D	D	D	D	D	D	D	D	A	D	D	AP	AP	AP	AP	AM	D	AP	A	MC	AM	A	AM	DM	AM	AM	A	A	D	A	DM	AM	DM	AM	AM	A	AM	AM	DM	AM	A	A	D	MC	D	D
19	D	A	AP	AP	AP	AP	AP	MC	AP	MC	MC	MC	DM	AP	AM	AM	AM	DP	AM	AM	AM	MC	AM	AP	A	A	D	MC	AP	AP	AM	AM	D	AM	D	AM	AP	AP	D	AP	AP	DM	DM	DM	AM	MC	AM	AM
20	MC	AM	A	AP	MC	AP	D	AP	D	A	AP	D	DM	AP	AP	AP	AP	AM	D	AM	AP	MC	AP	AP	AP	MC	AM	AM	AP	AP	MC	A	D	A	D	AP	AP	AP	AP	AP	D	AP	AP	AP	D	MC	A	A
21	AM	DM	AP	MC	MC	MC	MC	MC	MC	MC	AP	MC	DM	A	A	A	AM	AP	D	A	AM	MC	AM	AP	A	DM	A	AM	A	A	MC	AM	DM	AM	DM	AM	A	A	AP	AM	AP	AP	A	AM	MC	MC	AP	MC
22	MC	AP	AP	AM	A	MC	AM	MC	AM	AP	DM	AP	AP	DP	MC	AP	AP	MC	AM	AP	MC	AM	AM	DM	AP	AP	DM	DM	DM	DM	AP	AP	D	AP	D	AP	AP	D	D	D	AM	D	D	D	AM	AM	AM	A
23	AM	DM	DM	AP	MC	MC	MC	MC	MC	MC	A	DM	DM	A	AM	AM	AM	AM	DM	A	AM	MC	AM	AM	A	D	A	AM	AM	AM	MC	AM	DM	AM	DM	AM	AM	AM	AM	AM	DM	AM	AM	AM	DM	MC	MC	DP
24	AM	DM	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AM	AM	AM	AM	AM	DM	AM	AM	MC	AM	AM	AM	DM	AM	AM	AM	AM	MC	AM	DM	AM	DM	AM	AP	AP	AP	AM	DM	AM	AM	AM	DM	MC	MC	MC
25	AM	MC	DP	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AM	AM	AM	AM	AM	DM	A	AM	MC	AM	AM	AM	MC	MC	AM	AM	AM	MC	AM	DM	AM	DM	AM	AP	AP	AP	AM	DM	AP	AP	A	DM	MC	MC	MC
26	MC	AM	AM	AM	AM	AM	AM	AM	AM	AM	DM	AM	AM	DM	DM	DM	DM	DM	DM	AP	DM	AP	MC	MC	MC	AM	MC	DM	DM	DM	MC	DM	A	DM	AM	MC	MC	MC	MC	MC	AM	MC	MC	MC	AM	AM	AM	AM
27	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	AM	AM	AM	AM	DM	A	A	MC	A	A	A	DM	AM	AM	AM	AM	MC	AM	DM	AM	DM	AM	AM	AM	AM	AM	DM	AM	AM	AM	DM	MC	DM	DM
28	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AM	AM	AM	AM	AM	DM	AM	AM	MC	AM	AM	AM	DM	AM	AM	AM	AM	DM	AM	DM	AM	DM	AM	AM	AM	AM	AM	DM	AM	AM	AM	DM	MC	DM	DM
29	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AM	AM	AM	AM	AM	DM	DM	AM	MC	AM	AM	AM	DM	AM	AM	AM	AM	DM	AM	DM	AM	DM	AM	AM	AM	AM	AM	DM	AM	AM	AM	DM	MC	DM	DP
30	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AM	AM	AM	AM	AM	DM	AP	AP	MC	AM	AM	AM	DM	AM	AM	AM	AM	AP	A	D	A	D	AM	AM	A	AP	AM	AP	AP	AP	AP	AP	MC	DM	AP
31	MC	AM	AM	AM	AM	AP	AP	MC	AP	DM	DM	AP	DM	AM	A	DM	DM	MC	AM	AM	DM	MC	DM	DM	DM	AP	DM	DM	DM	DM	AM	DM	AM	D	AM	DM	DM	DM	DM	MC	AM	DM	DM	DM	AM	MC	AM	AM
32	AM	DM	DM	DM	MC	MC	MC	MC	MC	MC	AM	MC	DM	AM	AM	AM	AM	AM	DM	AP	AM	MC	AM	AM	AM	DM	AM	AM	AM	AM	DP	AM	DM	AM	DM	AM	AM	AM	AM	AM	DM	AM	AM	AM	DM	MC	DM	D
33	MC	AM	AM	AM	MC	AM	MC	MC	AM	AM	MC	AM	AM	DM	DM	DM	DM	DM	MC	A	MC	MC	MC	MC	MC	AM	DM	DM	DM	MC	MC	MC	AM	DM	AM	DM	DM	DM	DM	DM	AM	DM	DM	DM	MC	MC	AM	MC
34	AM	DM	DM	DM	DM	DM	DM	MC	MC	MC	AM	DM	DM	AM	AM	AM	AM	AM	AP	AP	AP	MC	AP	AM	A	DM	AP	AM	AM	AM	MC	AM	DM	AM	DM	AM	AM	AM	AM	AM	D	AM	AM	AM	D	MC	DM	AP
35	DM	AM	AM	AM	MC	AM	AM	MC	AM	AM	DM	AM	AM	DM	DM	DM	DM	DM	DM	AP	DM	MC	MC	MC	MC	MC	MC	DM	DM	DM	MC	DM	AM	DM	AM	DM	DM	DM	DM	DM	AM	DM	DM	DM	DM	MC	AM	MC
36	AM	MC	DM	MC	MC	MC	MC	MC	MC	MC	AM	DM	DM	AM	AM	AM	AM	AM	DM	A	A	MC	AM	A	A	DM	AM	AM	AM	AM	DM	AM	DM	AM	DM	AM	AM	AM	AM	AM	DM	AM	AM	AM	DM	MC	DM	AP
37	AP	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	MC	MC	AP	MC	AM	MC	AP	MC	MC	AP	AP	AP	MC	AM	DM	AM	DM	A	AM	AM	AP	AP	MC	AM	AP	A	DM	MC	DM	MC
38	AP	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	MC	MC	MC	AM	MC	AP	MC	MC	AM	AM	AP	MC	AP	D	AM	D	AP	AM	AM	AP	AP	MC	A	A	A	MC	MC	DM	MC
39	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AM	AP	AP	AM	AM	DM	MC	AM	DM	AM	MC	AM	MC	A	A	A	A	MC	AM	DM	AM	MC	AM	AM	A	AM	AM	MC	AM	AM	AM	MC	MC	DM	MC
40	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	A	A	A	A	A	DM	AP	AP	MC	AM	A	A	DM	AM	AM	AM	AM	MC	AM	DM	AM	DM	AM	AM	AM	AM	AM	MC	AM	AM	AM	MC	MC	MC	MC
41	MC	AM	AM	AM	MC	MC	AP	MC	AP	MC	DM	AM	AM	DM	DM	DM	DM	DM	AM	A	DM	MC	MC	MC	MC	MC	DM	DM	DM	DM	AM	DM	AM	DM	AM	DM	DM	DM	DM	DM	AM	DM	DM	DM	AM	MC	AM	AM
42	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	AM	AM	AM	A	DM	DM	AM	DM	AM	AM	AM	DM	AM	AM	AM	AM	MC	AM	DM	AM	DM	AM	AM	AM	AM	AM	MC	AM	AM	AM	MC	MC	MC	MC
43	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AM	AM	AM	AM	AM	DM	DM	AM	MC	AM	A	AP	MC	AP	AP	AP	AP	MC	AM	DM	AM	DM	AM	AP	AP	AM	AM	DM	AM	AM	AP	MC	MC	MC	MC
44	AM	MC	MC	MC	MC	MC	MC	MC	MC	MC	AM	MC	MC	AP	AP	AP	AP	AP	DM	AP	A	MC	AM	AM	A	MC	AM	AM	AM	AM	MC	A	DM	AM	DM	AM	AP	AP	AP	AM	MC	AM	AP	AM	AP	MC	AP	MC
45	MC	AM	AP	AP	AP	MC	MC	MC	MC	MC	MC	AM	MC	AP	AP	MC	AP	MC	AM	AM	DM	MC	D	MC	MC	AP	MC	DP	DP	DP	AM	AP	DP	DM	AP	DM	DM	DM	DM	DM	AM	DM	DM	DM	AM	MC	A	AM
46	MC	AM	MC	AM	AM	A	MC	MC	AM	A	MC	AM	MC	MC	MC	MC	MC	MC	AM	AP	MC	AM	MC	MC	MC	AM	DM	DM	DM	DM	AM	DM	AM	AP	MC	DM	DM	MC	MC	MC	AM	MC	MC	DM	MC	AM	A	A
47	MC	AM	AM	AM	AP	AP	MC	MC	AP	MC	MC	AM	MC	MC	MC	MC	MC	MC	MC	DM	MC	MC	MC	MC	MC	MC	MC	DM	MC	MC	MC	DM	AM	DM	AP	DM	DM	MC	MC	MC	AM	MC	MC	MC	AM	MC	MC	MC
48	DM	AP	MC	MC	MC	MC	MC	MC	MC	MC	MC	AP	AP	AP	AP	DM	DM	AP	DM	MC	AP	D	DM	A	MC	MC	AP	DM	DM	DM	AP	AP	AP	AP	MC	AP	DM	AP	MC	MC	DM	DM	DM	MC	A	MC	MC	AM

Table B18 – Frequency of occurrence of expert #9's responses.

Expert Number: 9

Occurrence of Answers Concerning Activation Characteristics:

Concept	ACTIVATING NC	AM	A	AP	DM	D	DP	Concept	BEING ACTIVATED NC	AM	A	AP	DM	D	DP
1	8	9	17	1	2	9	2	1	18	21	1	3	4	1	0
2	2	11	3	6	7	18	1	2	14	15	4	5	7	3	0
3	1	9	11	4	4	18	1	3	15	9	7	8	5	3	1
4	1	7	9	8	2	16	5	4	18	12	5	7	3	3	0
5	2	1	16	6	0	23	0	5	25	7	5	6	2	3	0
6	1	1	7	13	5	21	0	6	21	5	4	11	2	5	0
7	0	6	8	10	11	13	0	7	22	5	4	10	2	5	0
8	1	5	8	11	3	19	1	8	29	4	4	6	1	4	0
9	1	4	9	7	7	18	2	9	23	7	4	9	1	4	0
10	1	1	11	9	7	19	0	10	24	4	5	8	3	3	1
11	0	21	3	1	10	12	1	11	12	13	4	5	6	8	0
12	2	4	11	9	11	11	0	12	18	12	4	4	3	7	0
13	3	0	0	19	2	17	7	13	17	8	6	3	8	6	0
14	4	12	12	4	1	15	0	14	5	15	7	6	5	9	1
15	6	15	9	9	0	9	0	15	5	16	6	5	6	10	0
16	3	7	13	11	0	14	0	16	4	17	5	5	6	11	0
17	5	17	7	12	3	3	1	17	3	19	4	6	7	9	0
18	2	11	10	5	4	16	0	18	7	16	5	3	7	9	1
19	7	14	3	14	4	5	1	19	6	7	2	6	16	8	3
20	6	5	6	22	1	8	0	20	3	8	12	19	4	2	0
21	13	10	11	8	5	1	0	21	5	14	6	11	7	5	0
22	6	10	2	15	6	8	1	22	29	3	2	8	3	3	0
23	10	21	5	1	9	1	1	23	6	22	5	3	2	9	1
24	15	23	0	3	7	0	0	24	11	13	6	5	3	9	1
25	17	18	2	5	5	0	1	25	8	9	11	12	2	5	1
26	14	18	1	2	13	0	0	26	11	3	3	11	12	7	1
27	15	20	5	0	8	0	0	27	7	14	7	3	7	10	0
28	13	26	0	0	9	0	0	28	1	22	2	2	12	8	1
29	13	25	0	0	9	0	1	29	1	18	4	5	11	8	1
30	13	17	3	10	3	2	0	30	3	17	4	7	8	8	1
31	6	14	1	5	21	1	0	31	20	5	2	10	4	3	4
32	9	25	0	1	11	1	1	32	1	22	4	4	7	10	0
33	17	13	1	0	17	0	0	33	0	9	5	3	19	11	1
34	6	21	1	6	12	2	0	34	1	23	5	2	8	9	0
35	11	13	0	1	23	0	0	35	2	7	5	5	17	10	2
36	10	22	4	1	11	0	0	36	1	23	2	4	10	7	1
37	26	7	2	9	4	0	0	37	1	18	3	9	10	6	1
38	28	7	3	7	1	2	0	38	4	14	6	7	8	8	1
39	20	17	5	2	4	0	0	39	4	14	3	9	9	7	2
40	19	16	7	2	4	0	0	40	5	19	4	4	9	5	2
41	11	13	1	2	21	0	0	41	6	12	3	9	13	5	0
42	18	23	1	0	6	0	0	42	4	16	5	4	11	8	0
43	18	16	1	8	5	0	0	43	3	14	7	5	11	8	0
44	17	13	3	12	3	0	0	44	3	16	7	3	12	6	1
45	15	8	1	9	10	1	4	45	9	9	5	9	10	6	0
46	22	12	4	2	8	0	0	46	32	3	6	5	0	2	0
47	31	7	0	4	6	0	0	47	8	10	9	7	10	4	0
48	19	1	2	13	12	1	0	48	13	7	10	8	4	4	2
Sum:	488	596	239	309	337	304	31	Sum:	488	596	239	309	337	304	31
% :	21.2	25.9	10.4	13.4	14.6	13.2	1.3	% :	21.2	25.9	10.4	13.4	14.6	13.2	1.3

Appendix C

SOFTWARE DESCRIPTION

This appendix presents the software description, written in Portuguese. Four programs were developed in FORTRAN 77 / Microsoft [Mds95][Hem86] to calculate statistical parameters and to make the simulations according to FCM technique. The first program allows entering with each expert's data and storing them in the computer memory as files. The second program allows correcting the entered data by the first program and it also sets numeric equivalents for the gradations. The third program calculates statistical parameters: frequency of occurrence of the gradations for each expert, General Average Matrix, and the "energy" of each concept. And the fourth program makes the typical operation in FCMs, which is to allow selecting the activation of a concept or some concepts and a threshold criterion to check the stabilization of the system.

Programas Utilizados
Descrição do Programas

1. Introdução

Para calcular os parâmetros estatísticos e fazer as simulações de acordo com a técnica de Mapas Cognitivos Difusos (*Fuzzy Cognitive Maps*-FCM), foram desenvolvidos quatro programas na linguagem FORTRAN 77 / Microsoft.

Estas versões foram desenvolvidas com o objetivo de testar a proposta apresentada, numa visão acadêmica, sem maiores preocupações com a interface com o usuário. Entretanto, cuidados foram tomados para que o usuário tenha certo conforto ao usar o programa, que vai solicitando os dados requeridos numa seqüência didática, sempre perguntando por eventual correção e dando na tela as opções possíveis de resposta. Em vista disto, a maior dificuldade para o uso do programa é a limitação com relação aos nomes das pastas onde serão criados, lidos ou gravados os arquivos, que são fixadas pelo programa e não pelo usuário. Em outras versões esta limitação poderá ser corrigida.

As pastas atualmente definidas são:

Path1: **C:\Nossos Documentos\Nossos Arquivos\Lucia\Apoio Computacional-PesquisaFCM\LeArquivaEmocao**

Path2: **C:\Nossos Documentos\Nossos Arquivos\Lucia\Apoio Computacional-PesquisaFCM\PreparaEmocao**

Path3: **C:\Nossos Documentos\Nossos Arquivos\Lucia\Apoio Computacional-PesquisaFCM\AnalisaEmocao**

O usuário pode optar por outras pastas, mas para isto deve ter acesso aos programas fonte, lembrando de trocar não apenas os nomes dos arquivos, mas também o tamanho das variáveis caracteres que armazenam esses endereços, em todos os programas e subprogramas relacionados.

Usou-se a linguagem FORTRAN por produzir um programa executável de bom desempenho, ter ampla biblioteca matemática/estatística, estar acessível, servir para os propósitos da simulação, ser uma linguagem ainda bastante usada em setores da engenharia onde se exige cálculos pesados e ainda por ser a linguagem de alto nível onde a pesquisadora tinha melhor treinamento e apoio técnico.

Entretanto, os programas estão estruturados de tal forma que podem ser facilmente transladados para outras linguagens, inclusive versões mais novas do próprio FORTRAN, o que teria como vantagem a possibilidade de interfaces mais amigáveis com o usuário.

2. Os Programas

O programa **LeArquivaEmocao** é o primeiro do pacote e permite a entrada dos dados (opiniões) de cada especialista e a posterior armazenagem em arquivos magnéticos em computador (usou-se um computador pessoal – PC ou *Personal Computer*).

O segundo programa é o **CorrigeEmocao**, que permite corrigir ou completar as entradas de dados feitas pelo primeiro programa e também permite a entrada dos equivalentes numéricos desejados para as gradações dos conceitos fornecidas pelos especialistas.

O terceiro programa é o **PreparaEmocao**, que a partir dos dados gerados nos dois primeiros programas, realiza os cálculos dos parâmetros estatísticos, como freqüência de ocorrência de gradações de cada especialista, matriz média geral, “energia” de cada conceito e taxa de ocorrência de cada gradação (providenciando dados para a construção de um histograma, no caso com o auxílio do programa Microsoft Excel [Exc00]). Também gera dados que serão usados no quarto programa desenvolvido no pacote de simulação.

Finalmente o quarto programa, o **AnalisaEmocao**, utilizando-se de dados dos programas anteriores, realiza a típica operação em FCM, que permite selecionar a ativação de um ou mais conceitos e através de uma função limiar (*threshold*) estabelecer um critério para verificar a estabilização do sistema.

Os itens a seguir dão uma breve descrição das estruturas internas de cada um dos quatro programas.

3. Programa LeArquivaEmocao

3.1 – Introdução

Este programa lê e armazena em arquivo as matrizes de influências dos especialistas e é parte integrante do pacote de programação responsável pela simulação da pesquisa FCM (*Fuzzy Cognitive Maps*) da tese de doutorado da Prof[a]. Lúcia Helena Martins Pacheco, INE/CTC/UFSC/2002. Gera o banco de dados básico das opiniões dos especialistas. Gera ainda alguns arquivos para dados que serão utilizados em outros programas do processo de análise de emoções.

3.2 - Sub-rotinas chamadas (na ordem e hierarquia em que são chamadas)

- **ArqEsp** – Prepara os arquivos que guardarão os nomes dos especialistas, os equivalentes literais e os equivalentes numéricos, na primeira vez que o programa é rodado.

- **Dados** - Lê e armazena em disco os dados dos especialistas.
    - **AbrArq** - Cria os arquivos de dados para gravar os dados dos especialistas.
        - **Zero** - Inicializa a matriz literal dos especialistas.
    - **Zero** - Já descrita.
- **ArqImp** - Prepara os arquivos com os dados dos especialistas para impressão.
    - **Espec** - Lê os nomes e os dados dos especialistas que serão formatados para melhor visualização da impressão.
    - **Saidas** - Arquiva os dados dos especialistas (dados preparados para melhor visualização da impressão).

3.3 - Arquivos de dados acessados (em ordem alfabética)

- **emocao.tex** - Arquivo de acesso seqüencial que contém os nomes (até 36 caracteres) das emoções consideradas.
- **EqLiteral.dad** - Arquivo de acesso seqüencial com os equivalentes literais das gradações adotadas.
- **EqNumerico.dad** - Arquivo de acesso direto com os equivalentes numéricos das gradações adotadas.
- **'*nomes(nespec)*'.lit** - Arquivo de acesso direto que contém os dados literais do especialista *nespec* (por exemplo: *expert1 .lit*). Existe um arquivo deste tipo para cada especialista.
- **nomes.tex** - Arquivo de acesso seqüencial com os nomes dos especialistas (máximo oito caracteres) que forneceram as informações para o banco de dados.

3.4 – Estrutura do programa principal

1. Preparo dos arquivos que guardarão os nomes dos especialistas e os equivalentes literais. Este procedimento é feito somente na primeira vez que o programa é executado. Geração do arquivo para os equivalentes numéricos das gradações a ser preenchido pelo programa **CorrigeEmocao** (sub-rotina **ArqEsp**).

2. Leitura e armazenagem em arquivos em disco dos dados dos especialistas (sub-rotina **Dados**).

3. Preparo dos arquivos com os dados originais dos especialistas para impressão, visando facilitar a visualização (sub-rotina **ArqImp**).

3.5 – Estrutura das sub-rotinas

3.5.1 – Sub-rotina **ArqEsp**

Esta sub-rotina, na primeira vez que o programa é executado, prepara o arquivo de dados para serem gravados os nomes dos especialistas que responderam os questionários (são também os nomes dos arquivos de dados onde estarão armazenadas as matrizes parciais dos dados de cada entrevistado). Também armazena informação para verificar se o arquivo a ser preenchido é novo ('new') ou já existente ('old').

Gera, ainda, o arquivo com os equivalentes literais das gradações e o arquivo para os equivalentes numéricos das gradações, a ser preenchido pelo programa responsável por eventuais correções de dados de especialistas e por correção e/ou inclusão de equivalentes numéricos, o programa **CorrigeEmocao**.

Os passos de realização da tarefa são os seguintes:

1. Abertura do arquivo para gravação dos nomes dos especialistas e do 'status' do arquivo (se já está preenchido ou não).

2. Abertura e preenchimento do arquivo de equivalentes literais das opiniões dos especialistas.

3. Preparo do arquivo dos equivalentes numéricos das opiniões dos especialistas. Este arquivo deverá ser preenchido com o auxílio do programa **CorrigeEmocao**.

3.5.2 – Sub-rotina **Dados**

Esta sub-rotina lê os nomes dos conceitos/emoções e os armazena em arquivos de dados para posterior tratamento. A leitura dos dados é feita por página do formulário do especialista (cada página é uma linha da matriz de relações). Os dados de entrada são tratados como vetores, e armazenados em arquivos, um para cada especialista, com acesso direto por página (linha da matriz).

Os passos de realização da tarefa são os seguintes:

1. Leitura dos equivalentes literais de cada gradação.
2. Leitura dos nomes dos conceitos/emoções.
3. Leitura dos nomes dos especialistas quer responderam os questionários (são também os nomes dos arquivos de dados onde estão armazenadas as matrizes parciais dos dados de cada entrevistado). Também lê informação para verificar se o arquivo a ser preenchido é novo ('new') ou já existente ('old').
4. Escolha do Especialista.

5. Queima do arquivo velho, se existir e se desejar um novo, com o mesmo nome, em seu lugar.

6. Abertura do arquivo novo (sub-rotina **AbrArq**).

7. Preparo dos vetores que armazenarão provisoriamente os dados a serem lidos (sub-rotina **Zero**).

8. Escolha da página de dados.

9. Digitação dos dados (via teclado).

10. Visualização na tela dos resultados digitados para a página para a verificação de eventual correção.

11. Gravação dos dados da página completada no arquivo do especialista.

12. Verificação se se deseja ler uma nova página do mesmo especialista.

13.Verificação se se deseja ler os dados de um outro especialista. Pode ser a continuação da leitura de um outro especialista, que não seja aquele que estava sendo lido.

3.5.3 – Sub-rotina **AbrArq**

Esta sub-rotina cria os arquivos de dados para gravar os dados por especialista. Sinaliza ainda, nas matrizes de dados, se estas já estão formadas, para se evitar dupla digitação de dados.

Passos:

1. Geração dos arquivos dos especialistas.
2. Inicialização dos vetores que armazenarão provisoriamente os dados a serem lidos (sub-rotina **Zero**).
3. Geração dos arquivos com os nomes dos especialistas.

3.5.4 – Sub-rotina **Zero**

Esta sub-rotina coloca 'lixo' na matriz literal. Este 'lixo' visa facilitar a decepção, através de inspeção visual nos arquivos da matriz do especialista já preenchida, de algum erro na leitura e/ou armazenagem dos dados.

3.5.5 – Sub-rotina **ArqImp**

Esta sub-rotina prepara arquivos com os dados originais dos especialistas para impressão, visando facilitar a visualização.

Passos:

1. Leitura dos nomes dos especialistas já armazenados em arquivos, que terão seus dados ajustados para impressão. Lê ainda os dados dos especialistas (sub-rotina **Espec**).
2. Armazenamento dos resultados em arquivos magnéticos (sub-rotina **Saidas**).

3.5.6 – Sub-rotina **Espec**

Esta sub-rotina lê os dados já armazenados dos especialistas que preencheram os formulários para serem re-arranjados para uma melhor visualização da impressão.

Passos:

1. Leitura dos nomes dos especialistas que responderam aos questionários (são os nomes dos arquivos onde seus dados estão armazenados).
2. Leitura dos dados dos especialistas.

3.5.7 – Sub-rotina **Saidas**

Esta sub-rotina arquiva os dados dos especialistas, para posterior impressão, se desejado.

Passo:

1. Arquivamento dos dados dos especialistas, por especialista.

4. Programa CorrigeEmocao

4.1 – Introdução

Este programa permite a visualização e a correção dos arquivos criados pelo programa **LeArquivaEmocao,** parte integrante do pacote de programação responsável pela simulação da pesquisa que utiliza a técnica de Mapas Cognitivos Difusos (*Fuzzy Cognitive Maps*-FCM) da tese de doutorado da Prof^a.^ Lúcia Helena Martins Pacheco, INE/CTC/UFSC/2002. Permite ainda a troca/inclusão dos equivalentes numéricos das gradações.

4.2 - Sub-rotinas chamadas (na ordem e hierarquia em que são chamadas)

- **CorrEm** – Permite a visualização e a correção de dados dos arquivos dos especialistas e permite a inclusão/alteração dos equivalentes numéricos das gradações. Salva os dados corrigidos.
- **ArqImp** – Prepara os arquivos com os dados (corrigidos) dos especialistas para impressão.
    - **Espec** – Lê os nomes e os dados dos especialistas (corrigidos) que serão ajustados para melhor visualização da impressão.
    - **Saidas** – Arquiva os dados dos especialistas (corrigidos) numa forma que permite melhor visualização da impressão.

4.3 - Arquivos de dados acessados (em ordem alfabética)

- **emocao.tex** – Arquivo de acesso seqüencial que contém os nomes (até 36 caracteres) das emoções consideradas.

- **EqLiteral.dad** – Arquivo de acesso seqüencial com os equivalentes literais das gradações adotadas.
- **EqNumerico.dad** – Arquivo de acesso direto com os equivalentes numéricos das gradações adotadas.
- '*nomes(nespec)*'**.lit** – Arquivo de acesso direto que contém os dados literais do especialista *nespec* (por exemplo: expert1 .lit). Existe um arquivo deste tipo para cada especialista.
- **nomes.tex** – Arquivo de acesso seqüencial com os nomes dos especialistas (máximo oito caracteres) que forneceram as informações para o banco de dados.

4.4 – Estrutura do programa principal

1. Visualização e telas de correção de dados dos arquivos dos especialistas e inclusão/alteração dos equivalentes numéricos das gradações. Gravação dos arquivos corrigidos (sub-rotina **CorrEm**).
2. Preparo dos arquivos com os dados (corrigidos) dos especialistas para impressão. Gravação desses arquivos (sub-rotina **ArqImp**).

4.5 – Estrutura das sub-rotinas

4.5.1 – Sub-rotina **CorrEm**

Esta sub-rotina permite a visualização e a correção de dados dos arquivos dos especialistas e permite a inclusão/alteração dos equivalentes numéricos das gradações. Faz a gravação dos dados corrigidos.

Os passos de realização da tarefa são os seguintes:

1. Leitura dos equivalentes literais.
2. Leitura dos nomes dos conceitos/emoções.

3. Leitura dos nomes dos especialistas que responderam os questionários (são também os nomes dos arquivos de dados onde estão armazenadas as matrizes parciais (dos dados de cada entrevistado)).
4. Escolha do tipo de correção a ser feito.
5. Escolha do Especialista que terá seus dados corrigidos/alterados.
6. Escolha da página de dados.
7. Leitura dos dados de arquivo. Visualização, na tela, dos resultados digitados para a página e para o especialista escolhidos e verificação de alguma outra correção a ser feita.
8. Re-gravação dos dados da página corrigida no arquivo do especialista.
9. Verificação se se deseja ler uma nova página do mesmo especialista.
10. Verificação se se deseja ler os dados de um outro especialista. Pode ser a continuação da leitura de um outro especialista, que não seja aquele que estava sendo lido.
11. Leitura das gradações já existentes em arquivo.
12. Leitura dos novos equivalentes numéricos das gradações que serão incluídos ou alterados.
13. Gravação dos equivalentes numéricos novos/modificados.

4.5.2 – Sub-rotina **CorrEm**

Esta sub-rotina prepara arquivos com os dados originais dos especialistas para impressão, visando facilitar a visualização.

Os passos de realização da tarefa são os seguintes:

1. Leitura dos nomes dos especialistas armazenados em arquivos, que terão seus dados ajustados para impressão, e dos dados dos especialistas (sub-rotina **Espec**).
2. Esta etapa providencia a saída dos resultados em arquivos magnéticos (sub-rotina **Saidas**).

4.5.3 – Sub-rotina **Espec**

Esta sub-rotina lê os dados dos especialistas que preencheram os formulários.

Os passos de realização da tarefa são os seguintes:

1. Leitura dos nomes dos especialistas que responderam aos questionários (são os nomes dos arquivos onde seus dados estão armazenados).
2. Leitura dos dados dos especialistas.

4.5.4 – Sub-rotina **Saidas**

Esta sub-rotina arquiva os dados dos especialistas, para posterior impressão.

O passo:

1. Arquivamento dos dados dos especialistas, por especialista.

5. Programa PreparaEmocao

5.1 – Introdução

Este programa é o terceiro do pacote de simulação usado na pesquisa que utiliza a técnica de Mapas Cognitivos Difusos (*Fuzzy Cognitive Maps*-FCM) da tese de doutorado da Profª. Lúcia Helena Martins Pacheco, INE/CTC/UFSC/2002.

A partir dos dados gerados nos dois primeiros programas, realiza os cálculos dos parâmetros estatísticos, como freqüência de ocorrência de gradações de cada especialista, matriz media geral, "energia" de cada conceito e taxa de ocorrência de cada gradação, providenciando dados para a construção de um histograma (no caso, com o auxílio de um outro pacote, como o programa Excel/Microsoft). Também gera dados que serão usados no programa **AnalisaEmocao**.

5.2 - Sub-rotinas chamadas (na ordem e hierarquia em que são chamadas)

- **Espec** - Faz a leitura dos nomes dos especialistas armazenados em arquivos, permitindo a escolha dos especialistas que terão seus dados trabalhados.
- **Reader** - Faz a leitura dos dados dos especialistas escolhidos na etapa anterior. Estes dados são lidos de arquivos gerados na primeira fase deste trabalho, realizada pelos programas **LeArquivaEmocao** e **CorrigeEmocao**.
- **Dados** - Trabalha os dados dos especialistas escolhidos anteriormente, obtendo os parâmetros estatísticos desejados.
    - **OrdRea** - Pesquisa o conteúdo de um vetor real e guarda as posições dos seus valores em ordem crescente. Destrói o vetor original.
    - **Faixas** - Fornece informações úteis para análises estatísticas, como a separação das gradações por faixas, com suas larguras de faixa e limites superiores e inferiores, e outras.
        - **Ordena** - Ordena os dados de um vetor em ordem crescente. Faz a ordenação no próprio vetor de entrada, destruindo-o.
        - **Histog** - Obtém a freqüência de ocorrências de valores dentro de determinadas faixas num intervalo.
- **Saidas** - Arquiva os dados obtidos nesta etapa, e que servirão para posterior análise pelo programa **AnalisaEmocao** e para impressão.

5.3 - Arquivos de dados acessados (em ordem alfabética)

- **AtiOrden.doc** - Arquivo de acesso seqüencial que contém as freqüências percentuais de ocorrência de cada gradação na 'ativação' de cada conceito, ordenadas em ordem crescente.
- **CompFreq.xls** - Arquivo de acesso seqüencial que contém o número de cada gradação por especialista, preparado para ser entrada de aplicativo tipo planilha eletrônica Excel/Microsoft.
- **Energia.doc** - Arquivo de acesso seqüencial que contém a matriz de 'energia' do conceito, com conteúdo ordenado em ordem crescente, ou seja, os pesos com que um conceito ativa os outros ou é ativado pelos outros de forma positiva ou negativa, considerando todas as gradações positivas (primeiro caso) e negativas (segundo caso) são apresentados em ordem crescente.
- **EqLiteral.dad** - Arquivo de acesso seqüencial com os equivalentes literais das gradações adotadas.
- **EqNumerico.dad** - Arquivo de acesso direto com os equivalentes numéricos das gradações adotadas.
- **GradPerc.doc** - Arquivo de acesso seqüencial que contém os percentuais de cada gradação por linha (grau de um conceito ativando os outros) e por coluna (grau de um conceito sendo ativado pelos outros) e também dos percentuais de cada gradação e de seus respectivos desvios padrões percentuais nas respostas dos especialistas no total das respostas.
- **HistogramaMedia.doc** - Arquivo de acesso seqüencial que contém a distribuição dos valores da matriz média dentro de intervalos definidos pelo usuário, com o fim de traçar um histograma, num formato de impressão.

- **HistogramaMedia.xls** – Arquivo de acesso seqüencial que contém a distribuição dos valores da matriz média dentro de intervalos definidos pelo usuário, com o fim de traçar um histograma, num formato para ser trabalhado por um programa tipo planilha Excel/Microsoft.
- **HistogramaSTD.doc** – Arquivo de acesso seqüencial que contém a distribuição dos desvios padrão dos valores da matriz média dentro de intervalos definidos pelo usuário, com o fim de traçar um histograma, num formato de impressão.
- **HistogramaSTD.xls** – Arquivo de acesso seqüencial que contém a distribuição dos desvios padrão dos valores da matriz média dentro de intervalos definidos pelo usuário, com o fim de traçar um histograma, num formato para ser trabalhado por um programa tipo planilha Excel/Microsoft.
- **Media.doc** – Arquivo de acesso seqüencial que contem os valores da matriz media.
- **MedOrd.doc** – Arquivo de acesso seqüencial que contem os valores da matriz media ordenados.
- '*nomes(nespec)*'**.lit** – Arquivo de acesso direto que contém os dados literais do especialista *nespec* (por exemplo: *expert1 .lit*). Existe um arquivo deste tipo para cada especialista.
- **nomes.tex** – Arquivo de acesso seqüencial com os nomes dos especialistas (máximo oito caracteres) que forneceram as informações para o banco de dados.
- **Pontos.doc** – Arquivo de acesso seqüencial que contem os valores médios de cada gradação e os valores limites da faixa de cada gradação.
- **SdAtiOrd.doc** – Arquivo de acesso seqüencial que contem as freqüências percentuais de ocorrência de cada gradação 'sendo ativada' por cada conceito, ordenadas em ordem crescente.

- **STD.doc** - Arquivo de acesso seqüencial que contem os valores da matriz desvio padrão.
- **STDOrd.doc** - Arquivo de acesso seqüencial que contem os valores da matriz desvio padrão ordenados.

5.4 – Estrutura do programa principal

1. Leitura dos nomes dos especialistas armazenados em arquivos, permitindo a escolha dos especialistas que terão seus dados trabalhados (sub-rotina Espec).
2. Leitura dos dados dos especialistas escolhidos na etapa anterior. Estes dados são lidos de arquivos gerados na primeira fase deste trabalho, realizada pelos programas **LeArquivaEmocao** e **CorrigeEmocao** (sub-rotina **Reader**).
3. Tratamento dos dados dos especialistas escolhidos (sub-rotina **Dados**).
4. Saída dos resultados em arquivos para impressão e para posterior tratamento pelo programa **AnalisaEmocao** (sub-rotina **Saidas**).

5.5 – Estrutura das sub-rotinas

5.5.1 – Sub-rotina **Espec**

Esta sub-rotina permite a escolha dos especialistas que serão trabalhados pelo programa. Lê os nomes dos especialistas que preencheram os formulários, para a escolha entre os mesmos.

Os passos de realização da tarefa são os seguintes:

1. Leitura dos nomes dos especialistas que responderam aos questionários (são também os nomes dos arquivos de dados onde estão armazenadas as matrizes parciais (dos dados de cada entrevistado) e dos arquivos onde serão armazenados alguns resultados das analises feitas neste programa).
2. Leitura dos dados armazenados.
3. Escolha dos especialistas que serão analisados.

4. Verificação se a entrada de especialistas esta correta.

5.5.2 – Sub-rotina **Reader**

Esta sub-rotina lê os dados dos especialistas escolhidos e os equivalentes numéricos, para posterior tratamento dos mesmos.

Os passos de realização da tarefa são os seguintes:

1. Leitura dos dados dos especialistas.
2. Leitura dos equivalentes literais de cada gradação.
3. Leitura dos equivalentes numéricos.

5.5.3 – Sub-rotina **Dados**

Esta sub-rotina trabalha os dados dos especialistas escolhidos. Pesquisa, por linha, o grau de ativação de um conceito sobre os outros (o quanto um conceito 'causa' os outros). E por coluna, o quanto um conceito é ativado pelos demais. Faz ainda uma análise estatística/numérica dos dados apresentados.

Os passos de realização da tarefa são os seguintes:

1. Escolha do equivalente numérico para o cálculo da matriz média e das "energias" das ativações.
2. Pesquisa por linha: grau de ativação de um conceito sobre os outros, por especialista. Percentual em relação ao total, por especialista.
3. Pesquisa por coluna: grau de quanto um conceito é ativado pelos outros, por especialista. Percentual em relação ao total, por especialista.
4. Cálculo do percentual de cada gradação (**NC** – não causa, **AM** – aumenta muito, **A -** aumenta, **AP** – aumenta pouco, **DM** – diminui muito, **D -** diminui, **DP** – diminui pouco), por conceito ("ativando" e "sendo ativado"), em

relação ao total de especialistas. Cálculo do percentual de cada gradação no total de atribuições. Cálculo do desvio padrão por gradação.

5. Ordenação dos percentuais dos 'NC', 'AM', 'A ', 'AP', 'DM', 'D ' e 'DP' no "ativa" e no "é ativado" de cada conceito (sub-rotina **OrdRea**).
6. Obtenção das freqüências percentuais ponderadas das influências no "ativa" e no "e' ativado" de cada conceito.
7. Ordenação das freqüências ponderadas das influências "positivas" (AM, A e AP) e "negativas" (DM, D e DP) no "ativa" e no "é ativado" de cada conceito (sub-rotina **OrdRea**).
8. Pesquisa das gradações na matriz literal de cada especialista e substituição dos novos equivalentes numéricos na matriz numérica.
9. Inicialização das matrizes média e desvio padrão.
10. Cálculo da matriz média e da matriz desvio padrão.
11. Obtenção das faixas de cada gradação na matriz média (sub-rotina **Faixas**).

5.5.4 – Sub-rotina **OrdRea**

Esta sub-rotina pesquisa um vetor real e guarda as posições dos seus valores em ordem crescente. Destrói o vetor original.

5.5.5 – Sub-rotina **Faixas**

Esta sub-rotina fornece informações úteis para análises estatísticas, como a separação das gradações por faixas, com suas larguras de faixa e limites superiores e inferiores e outras.

Os passos a serem desenvolvidos:

1. Transferência do conteúdo da matriz de médias para um vetor.
2. Ordenação dos elementos da matriz média (sub-rotina **Ordena**). Armazenagem dos valores ordenados.

3. Solicitação do número de intervalos desejados para o histograma da matriz média. Geração dos intervalos. Obtenção do histograma da matriz média (sub-rotina **Histog**).

4. Transferência do conteúdo da matriz de desvios padrão para um vetor.

5. Ordenação dos elementos da matriz desvio padrão (sub-rotina **Ordena**).

6. Solicitação do número de intervalos desejados para o histograma da matriz desvio padrão. Geração dos intervalos. Obtenção do histograma da matriz desvio padrão (sub-rotina **Histog**).

7. Pesquisa da "largura de faixa" da gradação **AM**. A partir dos valores percentuais de ocorrência desta gradação em relação ao número total de respostas na matriz média, é obtido o número médio de ocorrências de **AM**.

8. Média, posição da média e limite inferior da faixa de **AM**.

9. Pesquisa da "largura de faixa" da gradação **DM**. A partir dos valores percentuais de ocorrência desta gradação em relação ao numero total de respostas na matriz média, é obtido o número médio de ocorrências de **DM**.

10. Média, posição da média e limite superior da faixa de **DM**.

11. Pesquisa da "largura de faixa" da gradação **A** . A partir dos valores percentuais de ocorrência desta gradação em relação ao número total de respostas na matriz média, é obtido o número médio de ocorrências de **A** .

12. Média, posição da média e limites da faixa **A** . O limite superior da faixa **A** é uma posição abaixo da posição do limite inferior de **AM**, no vetor de pesquisa.

13. Pesquisa da "largura de faixa" da gradação **D** . A partir dos valores percentuais de ocorrência desta gradação em relação ao número total de respostas na matriz média, é obtido o número médio de ocorrências de **D** .

14. Média, posição da média e limites da faixa **D** . O limite inferior da faixa **D** é uma posição acima da posição do limite superior de **DM**, no vetor de pesquisa.

15. Pesquisa da "largura de faixa" da gradação **AP**. A partir dos valores percentuais de ocorrência desta gradação em relação ao número total de respostas na matriz média, é obtido o número médio de ocorrências de **AP**.
16. Média, posição da média e limites da faixa **AP**. O limite superior da faixa **AP** é uma posição abaixo do limite inferior da faixa de **A** , no vetor de pesquisa.
17. Pesquisa da "largura de faixa" da gradação **DP**. A partir dos valores percentuais de ocorrência desta gradação em relação ao número total de respostas na matriz média, é obtido o número médio de ocorrências de **DP**.
18. Média, posição da média e limites da faixa **DP**. O limite inferior da faixa **DP** é uma posição acima do limite superior da faixa de **D** , no vetor de pesquisa.
19. Pesquisa da "largura de faixa" da gradação **NC**. A partir dos valores percentuais de ocorrência desta gradação em relação ao número total de respostas na matriz média, é obtido o número médio de ocorrências de **NC**. Para se levar em consideração os arredondamentos, serão adotados os limites obtidos a partir dos limites das faixas de **DP** (limite inferior) e de **AP** (limite superior) e, a partir destes limites, será obtida a largura prática de faixa de **NC** (a teórica também será calculada para verificações).
20. Média, posição da média e limites da faixa **NC**. O limite superior da faixa **NC** é uma posição abaixo do limite inferior de **AP** e uma posição acima do limite superior de **DP**, no vetor de pesquisa.
21. Média e limites da faixa **NC** dos positivos e dos negativos. Posição das médias das faixas positiva e negativa. Para esta etapa foram considerados como "zero" os números dentro da faixa -10^{-6} a $+10^{-6}$.

5.5.6 – Sub-rotina **Ordena**

Esta sub-rotina ordena os dados por ordem crescente. Faz a ordenação no próprio vetor de entrada.

5.5.7 – Sub-rotina **Histog**

Esta sub-rotina obtém a freqüência de ocorrências de valores dentro de determinadas faixas num intervalo.

O passo:

1. Distribuição das freqüências nos intervalos.

5.5.8– Sub-rotina **Saidas**

Esta sub-rotina arquiva os dados obtidos nesta etapa, e que servirão para posterior análise pelo programa **AnalisaEmocao** e para impressão.

Os passos:

1. Arquivamento das matrizes de ativação, por especialista.
2. Arquivamento dos percentuais de cada gradação por linha (grau de um conceito ativando os outros) e por coluna (grau de um conceito sendo ativado pelos outros) e também dos percentuais de cada gradação e de seus respectivos desvios padrões percentuais nas respostas dos especialistas no total das respostas.
3. Arquivamento da matriz média ordenada.
4. Arquivamento da matriz desvio padrão ordenada.
5. Arquivamento do histograma da matriz média.
6. Arquivamento do histograma da matriz desvio padrão.

7. Arquivamento dos valores médios de cada gradação e dos valores nos limites das faixas de cada gradação, considerando seus percentuais em relação ao número total de respostas.
8. Arquivamento das matrizes media e desvio padrão.
9. Arquivamento da matriz geral "ativando", ordenada de acordo com as freqüências percentuais de ocorrência das gradações.
10. Arquivamento da matriz geral "sendo ativado", ordenada de acordo com as freqüências percentuais de ocorrência das gradações.
11. Arquivamento da matriz de energia dos conceitos "ativando" e "sendo ativado", ordenadas pela energia, considerando a influência das 'energias' positiva e negativa.
12. Arquivamento do número de determinada gradação por cada especialista.

6. **Programa AnalisaEmocao**

6.1 – Introdução

Este programa é o quarto e último do pacote de simulação na pesquisa que *utiliza a técnica de Mapas Cognitivos Difusos (*Fuzzy Cognitive Maps-FCM) da tese de doutorado da Profª. Lúcia Helena Martins Pacheco, INE/CTC/UFSC/2002.

A partir dos bancos de dados disponibilizados pelos três programas anteriores, permite que se faça a "Análise do Padrão Escondido" nas relações entre as emoções.

6.2 - Sub-rotinas chamadas (na ordem e hierarquia em que são chamadas)

- **Inicio** – Lê os dados da matriz media preparada no programa **PreparaEmocao** para serem trabalhados.

- **Opcao** - Permite a escolha do tipo de ajuste a ser feito no vetor de saída a cada iteração e a escolha do "apelido" do arquivo de saída com os dados gerados.
- **VEstim** - Permite a entrada do vetor de estimulação e do número de iterações desejado.
- **Simula** - É a alma do programa. Simula a ativação da matriz dos conceitos, obtém as saidas brutas ajustadas. Prepara a nova entrada e re-inicia o processo, controlando o número de iterações e armazenando os resultados parciais e final.
  - **VetXMt** - Faz a multiplicação do vetor de ativação pela matriz dos conceitos.
  - **Regula** - Faz a regularização do vetor de saída.
  - **Normal** - Faz a normalização do vetor de saída.
  - **Triva** - Faz o ajuste do vetor de saída. Distribui seus valores em três faixas, que dependem do maior valor em módulo do conjunto. Atribui os valores **-1**, **0** e **+1** respectivamente aos valores da faixa 1 (menores valores), da faixa 2 (valores intermediários) e da faixa 3 (maiores valores).
  - **Septa** - Faz o ajuste do vetor de saída. Distribui seus valores em sete faixas, que dependem do maior valor em módulo do conjunto. Atribui os valores dos equivalentes numéricos respectivamente aos valores da faixa 1 (menores valores), das faixas 2, 3, 4, 5 e 6 (valores intermediários) e da faixa 7 (maiores valores).
  - **Sigmoi** - Faz o ajuste do vetor de saída por uma função 'sigmóide', cujo coeficiente é escolhido pelo usuário.
    - **Funcao** - Subprograma "Function" que calcula a função 'sigmóide' propriamente dita.

- **Imprim** - Imprime os vetores de entrada e saída a cada iteração.
  - **ImpLit** - No caso do ajuste septavalente, transforma a saída numérica numa saída literal, usando as gradações literais.

- **Fim** - Verifica se o usuário deseja analisar outros casos com a mesma matriz numérica, reinicializando o programa ou, se não desejado, encerrando-o.

6.3 - Arquivos de dados acessados (em ordem alfabética)

- **file1.doc** - Arquivos seqüenciais que contém os valores dos vetores de estimulação em cada iteração, de nome geral: **Vetores-Caso**'*caso*'), onde *caso* é uma identificação de três caracteres alfanuméricos dada pelo usuário, para auxiliar a organização dos arquivos gerados.
- **file2.xls** - Arquivos seqüenciais que contém os valores de saída para o uso em programas tipo planilha Excel/Microsoft, de nome geral: '*Descri*''*escolh*(*kod*'')*clamp*(*cntr*)'-**Caso**'*caso*', onde:

  Descri: descrição do caso;

  escolh: tipo de função de ajuste escolhida;

  kod: equivalente numérico de '*escolh*';

  clamp: opção do usuário, que depende de '*cntr*';

  cntr: indica se se quer permitir que as ativações de entrada variem de acordo com a evolução do programa (*cntr*=1) ou se se quer mantê-las fixas (*cntr*=2);

  caso: identificação de três caracteres alfanuméricos dada pelo usuário, com o fim de organizar os arquivos gerados.
- **file3.doc** - Arquivos seqüenciais que contém os valores da saída literal da opção "septavalente" para a função 'threshold', de nome geral **Septavalente-Saida Literal-Caso**'*caso*', onde *caso* é uma identificação de três

caracteres alfanuméricos dada pelo usuário com o fim de organizar seus arquivos.

- **EqLiteral.dad** – Arquivo de acesso seqüencial com os equivalentes literais das gradações adotadas.
- **Media.doc** – Arquivo de acesso seqüencial que contem os valores da matriz media.
- **nomes.tex** – Arquivo de acesso seqüencial com os nomes dos especialistas (máximo oito caracteres) que forneceram as informações para o banco de dados.

6.4 – Estrutura do programa principal

1. Leitura dos dados da matriz média, conforme preparada no programa **PreparaEmocao**, que será agora tratada (sub-rotina **Inicio**).
2. Escolha do ajuste a ser feito no vetor de saída, a cada iteração. Escolha do 'sobrenome' dos arquivos que armazenarão os dados de saída (sub-rotina **Opcao**).
3. Entrada do vetor de estimulação e do número de iterações desejado (sub-rotina **Vestim**).
4. Multiplicação do vetor de entrada pela matriz média obtida de acordo com os critérios estabelecidos no programa **PreparaEmocao**, gerando o vetor dos conceitos ativados (simula a ativação da matriz dos conceitos). Ajuste do vetor de saída e transformação deste vetor modificado como o novo vetor de entrada. Geração em arquivo para impressão, a cada iteração, dos vetores Input (entrada) e Output (saída) e outros dados de interesse (sub-rotina **Simula**).
5. Saída do programa. Verificação se se deseja rodar outro caso com a mesma matriz média (sub-rotina **Fim**).

6.5 – Estrutura das sub-rotinas

6.5.1 – Sub-rotina **Inicio**

Esta sub-rotina lê os dados da matriz média, preparada no programa **PreparaEmocao**, que serão agora tratados.

A tarefa a ser efetivada é:

1. Leitura da matriz média a ser trabalhada e do equivalente numérico usado na sua montagem.

6.5.2 – Sub-rotina **Opcao**

Esta sub-rotina permite a escolha do tipo de ajuste que será feito no vetor de saída, a cada iteração. Também permite a escolha do 'sobrenome' dos arquivos onde serão armazenados os dados de saída gerados e da escolha do coeficiente da parte exponencial da função 'sigmóide', se usada.

Os passos de realização da tarefa são os seguintes:

1. Entrada do 'sobrenome' dos arquivos onde serão gravados dos os dados de saída.
2. Escolha do ajuste do vetor de saída.
3. Escolha do coeficiente da parte exponencial da função 'sigmóide', se usada.

6.5.3 – Sub-rotina **VEstim**

Esta sub-rotina permite a entrada do vetor de estimulação e o número de iterações desejado. A entrada dos dados é feita da seguinte forma:

1 - o vetor é inicialmente zerado;

2 - se a entrada é um número inteiro positivo entre 1 e 48, a posição do vetor correspondente a este numero é preenchida com +1;

3 - se a entrada é um número inteiro negativo entre -1 e -48, a posição correspondente ao módulo deste número é preenchida com -1.

Os passos de realização da tarefa são os seguintes:

1. Inicialização dos vetores de entrada.
2. Leitura do número de iterações.
3. Leitura dos valores de estimulação.
4. Verificação se se deseja fazer alguma alteração nas estimulações fornecidas.
5. Verificação se o usuário deseja manter as estimulações de entrada fixas, à medida que o processo avança, ou se deixa as entradas serem livremente ajustadas durante a evolução do programa.

6.5.4 – Sub-rotina **Simula**

Esta é a sub-rotina principal do programa. Multiplica o vetor de entrada pela matriz média obtida de acordo com os critérios estabelecidos no programa **PreparaEmocao**, gerando o vetor dos conceitos ativados, sendo assim responsável pela simulação da ativação da matriz dos conceitos.

Obtém a saída 'bruta' (*unbounded*), trata-a e gera a saída ajustada, tornando este vetor modificado a nova entrada do sistema na iteração seguinte, reiniciando o processo.

Controla o número de iterações e providencia a parada do programa por dois critérios:

1 - se o número máximo de iterações fornecido foi alcançado;

2 - se houve convergência, que é considerada atingida se ocorrerem duas saídas iguais, a menos de uma diferença de 0,000001, em módulo. Esta pesquisa é feita nos últimos 24 valores obtidos, que são armazenados e atualizados a cada iteração.

Imprime, para cada iteração, os vetores *Input* (entrada) e *Output* (saída), além de outros parâmetros de interesse.

As etapas realizadas ela sub-rotina **Simula** são:

1. Multiplicação do vetor de ativação pela matriz dos conceitos (sub-rotina **VetXMt**).
2. Regularização do vetor de saída, para a opção de ajuste 1 (sub-rotina **Regula**).
3. Normalização do vetor de saída para a opção de ajuste 2 (sub-rotina **Normal**).
4. Função trivalente, para a opção 3 (sub-rotina **Triva**).
5. Função septavalente, para a opção 4 (sub-rotina **Septva**).
6. Função sigmóide, para a opção de ajuste 5 (sub-rotina **Sigmoi**).
7. Impressão dos vetores Input, Output "bruto" e Output ajustado em cada iteração (sub-rotina **Imprim**).
8. Verificação se o número máximo de iterações foi atingido. Se foi, imprime mensagem indicando ser esta a última iteração (sub-rotina **Imprim**) e sai. Caso contrário, segue para o etapa 9.

9. Teste de convergência, se solicitado. No caso de convergência, impressão dos números das iterações coincidentes e da última iteração (sub-rotina **Imprim**).
10. Armazenamento da nova saída para comparação com as saídas anteriores na verificação da convergência.
11. Preparo do novo vetor de entrada.
12. Fim da iteração. Retornar ao início, para uma nova iteração.

6.5.5 – Sub-rotina **VetXMt**

Esta sub-rotina multiplica o vetor de ativação pela matriz dos conceitos.

6.5.6 – Sub-rotina **Regula**

Esta sub-rotina regulariza o vetor de saída.

Passos:
1. Pesquisa do maior valor em módulo.
2. Regularização do vetor de saída. Obtenção da saída ajustada (regularizada).

6.5.7 – Sub-rotina **Norma**

Esta sub-rotina normaliza o vetor de saída.

Passos:
1. Cálculo da média.
2. Cálculo do desvio padrão.
3. Normalização do vetor de saída. Obtenção da saída ajustada (normalizada).

6.5.8 – Sub-rotina **Triva**

Esta sub-rotina ajusta o vetor bruto de saída (Outpt), de acordo com as faixas a seguir, obtendo-se o vetor de saída ajustado (Output). Se:

$$\begin{array}{llllll} & Outpt(k) & \geq & 0{,}5.Outpt_{máx} & \Rightarrow & Output(k) = 1 \\ 0{,}5.Outpt_{máx} > & Outpt(k) & > & -0{,}5.Outpt_{máx} & \Rightarrow & Output(k) = 0 \\ & Outpt(k) & \leq & -0{,}5.Outpt_{máx} & \Rightarrow & Output(k) = -1 \end{array}$$

Os passos de execução são:

1. Pesquisa do maior valor em módulo.
2. Aplicação da função trivalente.

6.5.9 – Sub-rotina **Septva**

Esta sub-rotina ajusta o vetor bruto de saída (Outpt), de acordo com as faixas a seguir, obtendo-se o vetor de saída ajustado (Output).

Usa como parte do critério de ajuste os valores dos equivalentes numéricos das emoções (*eqNu*) usados no cálculo da matriz média, que irão definir os limites internos do intervalo da seguinte forma:

$$\begin{aligned} limite(1) &= (eqNu(2)+eqNu(3)) / 2 \\ limite(2) &= (eqNu(3)+eqNu(4)) / 2 \\ limite(3) &= (eqNu(4)+eqNu(1)) / 2 \\ limite(4) &= (eqNu(1)+eqNu(7)) / 2 \\ limite(5) &= (eqNu(7)+eqNu(6)) / 2 \\ limite(6) &= (eqNu(6)+eqNu(5)) / 2. \end{aligned}$$

Com estes limites e se fazendo a consideração $Output_{max} = V_{máx}$, tem-se:

$$\begin{array}{lcccccccl}
 & & Outpt(k) & \geq & limite(1).V_{máx} & \Rightarrow & Output(k) & = & eqNu(2) \quad (AM)\,; \\
limite(1).V_{máx} & > & Outpt(k) & \geq & limite(2).V_{máx} & \Rightarrow & Output(k) & = & eqNu(3) \quad (A\ \ )\,; \\
limite(2).V_{máx} & > & Outpt(k) & \geq & limite(3).V_{máx} & \Rightarrow & Output(k) & = & eqNu(4) \quad (AP)\,; \\
limite(3).V_{máx} & > & Outpt(k) & \geq & limite(4).V_{máx} & \Rightarrow & Output(k) & = & eqNu(1) \quad (NC)\,; \\
limite(4).V_{máx} & > & Outpt(k) & \geq & limite(5).V_{máx} & \Rightarrow & Output(k) & = & eqNu(7) \quad (DP)\,; \\
limite(5).V_{máx} & > & Outpt(k) & \geq & limite(6).V_{máx} & \Rightarrow & Output(k) & = & eqNu(6) \quad (D\ \ )\,; \\
limite(6).V_{máx} & > & Outpt(k) & & \Rightarrow & \Rightarrow & Output(k) & = & eqNu(5) \quad (DM)\,,
\end{array}$$

onde as letras entre parênteses são os respectivos equivalentes literais das gradações, apresentados no item 5.5.3.

Os passos de execução são:

1. Obtenção dos limites das faixas.
2. Aplicação da função septavalente.

6.5.8 – Sub-rotina **Sigmoi**

Esta sub-rotina ajusta a função de saída 'bruta' pela "sigmóide".

Os passos de execução são:

1. Pesquisa do maior valor em módulo.
2. Aplicação da função "sigmóide" (subprograma 'Function' **Funcao**).

6.5.8 – Subprograma "Function" **Funcao**

Este subprograma é a função sigmóide.

6.5.8 – Sub-rotina **Imprim**

Esta sub-rotina imprime os vetores de entrada e de saída a cada iteração.

Realiza os seguintes passos:

1. Abertura do arquivo para armazenamento dos vetores de entrada (*Input*) e saída (*Output*). Registro do cabeçalho.
2. Arquivamento dos vetores de entrada (Input) e saída (Output).
3. Arquivo de saída para uso no Excel.

6.5.9- Sub-rotina **ImpLit**

Esta sub-rotina, no caso do uso do ajuste septavalente, transforma a última saída numérica, já ajustada, numa saída literal, usando as gradações literais nesta transformação.

Realiza os passos:

1. Leitura dos equivalentes literais de cada gradação.
2. Obtenção da saída literal.
3. Abertura do arquivo para impressão. Impressão da saída literal.

6.5.9- Sub-rotina **Fim**

Esta sub-rotina verifica se o usuário deseja analisar outros casos com a mesma matriz numérica, reinicializando o programa ou, se não desejado, encerrando-o.

7. Resumo

Como finalização deste apêndice apresenta-se um resumo geral do pacote de programação utilizado, mostrado na Tabela C1, a seguir.

Tabela C1 – Tarefas gerais desempenhadas pelos programas desenvolvidos.

Programa	Tarefa
1º) **LeArquivaEmocao**	• Tabulação das respostas dos especialistas aos questionários e outras entradas de dados de controle em arquivos de computador.
2º) **CorrigeEmocao**	• Correções de dados em arquivos prévios de computador (se necessárias). • Declaração e correção de equivalentes numéricos.

3º) **PreparaEmocao**	• Seleção do equivalente numérico desejado.
	• Cálculo de:
	  • Freqüência de ocorrência de cada gradação.
	  • "Energia" of cada conceito.
	  • Matrizes média e de desvios padrão.
	• Geração de arquivos para análises gráficas.

4th) **AnalisaEmocao**	• Seleção da função de ajuste. • Seleção do critério de estabilização (convergência). • Seleção do(s) conceito(s) ativo(s). • Simulação dos Mapas Cognitivos Difusos (FCM). • Geração dos arquivos de resultados (saídas do propgrama).

Appendix D

USER INTERFACE

This appendix presents, in a summarized way, and describes, in Portuguese, the directions of how the user can interact with the programs developed. These programs allow the users entering with new data, calculating statistical parameters, and simulating FCM technique. In the latter, several possibilities to combine the numeric parameters are available.

MANUAL DO USUÁRIO

1. Introdução

Este manual mostra em linhas gerais e de forma resumida como usar os programas desenvolvidos para calcular os parâmetros estatísticos e fazer as simulações de acordo com a técnica de Mapas Cognitivos Difusos (*Fuzzy Cognitive Maps-FCM*), da tese de doutorado da Prof[a]. Lúcia Helena Martins Pacheco, INE/CTC/UFSC/2002. Foram desenvolvidos quatro programas, na linguagem FORTRAN 77, que são detalhadamente apresentados no *Appendix C* da citada tese de doutorado. Maiores detalhes podem ser obtidos naquele Apêndice.

2. O Roteiro

A seguir são apresentados os passos necessários para executar com sucesso os programas desenvolvidos num computador pessoal (PC), considerando uma plataforma mínima PC486, Windows 3.1, 4 Mb de memória RAM, cerca de 10 Mb de espaço em disco e monitor VGA.

1 – Criar as pastas necessárias, de acordo com os caminhos a seguir:

Path1: **C:\Nossos Documentos\Nossos Arquivos\Lucia\Apoio Computacional-PesquisaFCM\LeArquivaEmocao**

Path2: **C:\Nossos Documentos\Nossos Arquivos\Lucia\Apoio Computacional-PesquisaFCM\PreparaEmocao**

Path3: **C:\Nossos Documentos\Nossos Arquivos\Lucia\Apoio Computacional-PesquisaFCM\AnalisaEmocao**

Observação: conforme discutido no Apêndice C, o usuário pode optar por outras pastas, mas para isto deve ter acesso aos programas fonte, lembrando de trocar não apenas os nomes dos arquivos, mas também o tamanho das variáveis caracteres que armazenam esses endereços, em todos os programas e subprogramas relacionados.

2. Executar o programa **LeArquivaEmocao**.

3. Seguir as instruções na tela. O programa cria e gerencia os arquivos necessários e orienta como entrar com os dados dos especialistas e todas as operações necessárias.

4. Se for desejado ver os conteúdos dos arquivos gerados, pode-se associá-los ao *Notepad* ou *Word* da Microsoft (ou equivalentes) e abri-los com o aplicativo escolhido. Os arquivos são gerados na pasta **Path1:** *C:\Nossos Documentos\Nossos Arquivos\Lucia\Apoio Computacional-PesquisaFCM\LeArquivaEmocao\xxx*, onde '*xxx*' descreve o nome, características gerais e o tipo de saída o arquivo representa, por exemplo, *emocao.tex*, *profpsi.lit*, *EqLiteral.dad* etc..

5. Executar o programa **CorrigeEmocao**.

6. Seguir as instruções na tela. O programa gerencia os arquivos necessários e orienta como entrar com os dados para eventuais correções/complementações dos dados já tabulados dos especialistas. Também orienta a forma adequada de entrar com os equivalentes numéricos desejados e outras operações necessárias.

7. Se for desejado ver os conteúdos dos arquivos gerados/modificados, pode-se associá-los ao *Notepad* ou *Word* da Microsoft (ou equivalentes) e abri-los com o aplicativo escolhido. Os arquivos são gerados na pasta "**Path1**: *C:\Nossos Documentos\Nossos Arquivos\Lucia\Apoio Computacional-PesquisaFCM\LeArquivaEmocao\xxx*", onde '*xxx*' descreve o nome e o tipo de saída do arquivo, conforme já descrito.

8. Executar o programa **PreparaEmocao**.

9. Seguir as instruções na tela. O programa gerencia os arquivos necessários e orienta como entrar com os dados necessários para esta etapa e com os procedimentos adequados outras operações necessárias.

10. Os arquivos gerados nesta etapa tem terminação *.doc* e *.xls*, de forma que os primeiros podem ser visualizados com os programas *Notepad* ou *Word* da Microsoft (ou equivalentes) e os segundos com o Excel/Microsoft (ou equivalente). Neste último caso, o usuário deverá ter certa habilidade com o aplicativo, pois os dados exigirão certo re-trabalho para a correta visualização e apresentação na planilha eletrônica. Os arquivos são gerados na pasta "*Path2: C:\Nossos Documentos\Nossos Arquivos\Lucia\Apoio Computacional-PesquisaFCM\PreparaEmocao*", onde '*xxx*' descreve o nome e o tipo de saída do arquivo.

11. Executar o programa **AnalisaEmocao**.

12. Seguir as instruções na tela. O programa gerencia os arquivos necessários e orienta como entrar com os dados necessários para esta etapa e com os procedimentos adequados outras operações necessárias.

13. Os arquivos gerados nesta etapa tem terminação **.doc** e **.xls**, de forma que os primeiros podem ser visualizados com os programas *Notepad* ou *Word* da Microsoft (ou equivalentes) e os segundos com o Excel/Microsoft (ou equivalente). Neste último caso, o usuário deverá ter certa habilidade com o aplicativo, pois os dados exigirão certo re-trabalho para a correta visualização e apresentação na planilha eletrônica. Os arquivos são gerados na pasta "**Path3:** *C:\Nossos Documentos\Nossos Arquivos\Lucia\Apoio Computacional-*

PesquisaFCM\AnalisaEmocao", onde '**xxx**' descreve o nome e o tipo de saída do arquivo.

3. **Conclusão**

Com o roteiro fornecido, o usuário deverá ter sucesso na utilização do pacote apresentado no Apêndice C. Como qualquer pacote computacional, lhe será exigido alguma atenção e um pouco de treinamento para usufruir todo o potencial do pacote, não só dos programas em si, mas dos outros aplicativos usados em apoio.

Futuras versões podem ser desenvolvidas para incorporar o tratamento gráfico aos programas utilizados nesta simulação FCM.

Appendix E

NUMERIC DATA

This appendix presents the numeric parameters that are used in simulations. Each numeric equivalent proposed by the software (*linear, golden ratio, reverse golden ratio, square ratio* and *exponential ratio*) generates:

- a general average matrix (Tables E1, E4, E7, E10, E13)
- a standard deviation matrix (Tables E2, E5, E8, E11, E14)
- a histogram of general average matrix (Figures E1, E2, E3, E4, E5)
- a table of "energy of activation" of each concept (Tables E3, E6, E9, E12, E15)

During the simulations, the user chooses, through the selection of the numeric equivalent, one of these general average matrices to be the FCM connection matrix. The standard deviation matrices give an idea about how much the experts' responses match. The histograms of general average matrix provide visual information about the distribution of the values in the general average matrices. The interconnections among the concepts, explained in Chapter 7, are shown in "energy of activation" tables. These numeric data provide a good idea about the experts' values collected.

Table E1 – General Average Matrix using *linear* numeric equivalent.

Average Matrix

Equivalent Numeric: Fixed (NC= .00 AM= 1.00 A = .67 AP= .33 DM= -1.00 D = -.67 DP= -.33) with Linear Ratio series.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	.8	-.2	-.1	-.1	.0	-.2	.1	.1	.0	-.1	.6	.0	-.1	.7	.3	.0	.7	.3	.1	.3	.5	.0
2	-.1	.9	.6	.4	.5	.5	.3	.3	.9	.4	-.2	.9	.9	-.4	-.3	-.1	-.4	-.1	.0	.4	-.3	.3
3	-.2	.6	.9	.6	.6	.4	.4	.4	.5	.6	-.3	.7	.7	-.3	-.1	.1	-.2	.2	-.3	-.1	-.2	.1
4	-.1	.6	.1	.8	.7	.0	.1	.3	.7	.2	-.3	.7	.2	-.1	.4	.1	.4	-.1	.6	.3	.0	.9
5	-.2	.3	.5	.3	.6	.2	-.1	.0	.3	.3	-.2	.3	.5	-.3	-.1	-.1	-.2	-.1	-.1	.1	-.3	.1
6	-.3	.6	.6	.3	.4	.8	.1	.1	.6	.6	-.1	.7	.6	-.6	-.3	-.1	-.1	.0	-.1	-.1	-.2	.0
7	-.2	.5	.4	.6	.4	.4	.7	.7	.7	.4	-.4	.9	.5	-.4	.1	-.1	.3	-.1	.6	.6	.2	.6
8	-.1	.7	.7	.7	.3	.2	.6	.9	.7	.2	-.6	.7	.3	-.3	.1	-.1	.1	-.1	.6	.7	.4	.5
9	-.2	.9	.4	.6	.5	.3	.2	.2	.7	.3	-.4	.7	.4	-.4	.2	-.1	-.3	-.2	.0	.3	-.5	.5
10	-.2	.7	.5	.4	.5	.5	.3	.1	.5	.8	-.4	.6	.8	-.4	-.2	-.3	-.4	-.1	-.2	-.5	-.3	.1
11	.7	-.4	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2	.9	-.2	-.4	.5	.3	.2	.5	.6	.0	.0	.5	-.2
12	-.1	.8	.4	.6	.4	.4	.4	.3	.7	.5	-.3	.9	.6	-.5	.3	.0	-.2	-.2	.3	.1	.0	.5
13	-.2	.4	.4	.3	.4	.3	.3	.3	.3	.5	-.3	.4	.7	-.4	-.3	-.2	-.4	-.3	-.4	-.5	-.2	.1
14	.6	-.4	-.4	-.2	-.2	-.1	-.1	-.1	-.1	-.4	.4	-.2	-.3	.9	.1	.3	.5	.5	.0	.6	.6	-.3
15	.4	-.2	-.1	-.2	-.1	-.1	-.1	-.1	.0	-.1	.3	-.3	-.1	.3	.9	.5	.7	-.1	.4	.2	.6	-.1
16	.0	-.1	.0	.1	.1	.1	-.1	-.1	.0	.0	.1	.1	.0	.1	.4	.7	.6	.2	.3	.2	.4	-.1
17	.5	-.3	.0	-.1	-.2	.1	.0	.0	.1	-.1	.2	-.1	-.1	.3	.6	.6	.9	.4	.5	.4	.6	.1
18	.4	-.3	-.3	-.2	.0	-.1	-.1	-.1	-.1	.0	.6	.0	-.3	.5	.0	.0	.4	.9	-.1	.2	.3	.0
19	.0	.0	.1	.1	.2	.0	.6	.3	.3	-.1	-.3	.1	-.2	.3	.6	.4	.7	.0	.9	.7	.6	.3
20	.1	.3	.3	.2	.1	.3	.2	.2	.1	.3	.1	.1	-.3	.5	.1	.3	.5	.7	.3	.9	.5	.1
21	.5	-.1	.0	.0	.0	.0	.0	.0	.0	.0	.4	.0	-.5	.5	.4	.4	.6	.3	.1	.3	.8	-.1
22	.0	.0	.0	.8	.3	-.2	.4	.3	.8	.0	-.3	.3	.2	-.1	.4	.2	.2	-.1	.6	.2	.0	.9
23	.6	-.3	-.3	.0	-.1	-.1	-.1	-.1	-.1	-.1	.4	-.1	-.3	.4	.4	.5	.7	.4	.1	.2	.7	.0
24	.9	-.6	-.1	-.1	-.1	-.1	.0	.0	.0	-.1	.4	-.4	-.3	.6	.4	.3	.4	.6	-.3	.1	.4	.0
25	.9	-.4	-.3	-.3	-.1	-.1	-.1	.0	.0	.0	.4	-.2	-.1	.3	.4	.4	.7	.4	.0	.5	.6	-.1
26	-.1	.5	.7	.4	.4	.3	.0	.1	.7	.4	-.3	.7	.6	-.6	-.2	.0	-.6	-.1	-.1	-.1	-.1	.5
27	.6	-.2	-.2	-.2	.0	-.2	.0	.0	-.1	-.1	.5	-.1	-.2	.5	.3	.4	.5	.9	-.3	.5	.6	-.2
28	.8	-.1	.0	-.1	.0	.0	.0	.0	-.1	.0	.6	-.1	-.2	.6	.4	.5	.6	.7	.0	.5	.4	.0
29	.9	-.3	-.2	-.2	-.2	-.2	-.3	-.3	-.2	-.2	.4	-.2	-.2	.6	.6	.4	.6	.6	-.1	.1	.6	-.1
30	.6	-.3	-.4	-.2	.0	-.1	-.1	-.2	-.2	-.2	.6	-.2	-.3	.6	.7	.4	.7	.4	-.1	.2	.4	-.1
31	.0	.4	.2	.3	.5	.1	.1	.1	.2	-.2	-.4	.2	-.2	.5	.6	.2	.3	-.4	.9	.8	-.1	.4
32	.6	-.4	-.2	-.2	-.1	-.1	.0	.0	.0	-.1	.3	-.3	-.2	.3	.4	.5	.8	.4	.0	.2	.6	-.1
33	-.2	.6	.4	.5	.3	.6	.2	.2	.5	.4	-.3	.5	.3	-.4	-.4	-.4	-.7	-.1	-.4	-.2	-.5	-.1
34	.5	-.2	-.3	-.2	-.2	-.3	-.1	.0	.0	-.1	.4	-.3	-.3	.5	.5	.6	.7	.4	.0	.3	.5	-.1
35	-.1	.5	.6	.4	.4	.6	.3	.2	.5	.3	-.3	.7	.4	-.3	-.1	-.2	-.3	-.2	-.4	-.1	-.4	.2
36	.6	.0	-.1	.0	.0	-.1	.0	.0	-.1	.0	.4	-.3	-.3	.4	.5	.4	.7	.3	.0	.4	.5	-.2
37	.4	-.1	-.2	-.1	-.1	-.1	-.1	-.1	-.1	-.1	.1	-.2	-.1	.2	.2	.4	.6	.3	.0	.2	.5	-.1
38	.4	-.1	-.1	-.2	-.1	.0	.0	.0	.0	-.1	.3	-.2	.0	.1	.4	.3	.5	.3	.0	.1	.3	.0
39	.6	-.3	-.1	-.1	.0	.0	-.1	-.1	-.1	.0	.6	-.2	-.1	.4	.1	.3	.7	.8	-.3	.2	.5	-.1
40	.9	-.4	-.1	.0	.0	.0	.0	.0	.0	.0	.5	-.3	-.2	.4	.4	.3	.5	.3	-.1	.3	.4	-.1
41	-.1	.3	.4	.3	.3	.0	.2	.1	.1	.0	-.4	.2	.6	-.4	.3	.1	.0	-.5	.5	.4	.0	.1
42	.6	-.2	-.3	-.2	-.2	-.1	-.2	-.2	-.2	-.2	.7	-.2	-.2	.6	.2	.4	.5	.8	-.4	.1	.5	-.2
43	.5	.0	-.1	-.2	-.1	-.1	-.1	.0	.0	.0	.5	-.3	-.1	.4	.4	.5	.8	.6	-.2	.0	.5	-.1
44	1.0	-.4	-.2	-.2	-.1	-.1	.1	.1	-.1	.0	.4	-.3	-.1	.3	.4	.3	.6	.3	.1	.5	.4	.0
45	.0	.2	.6	.4	.3	.2	.1	.3	.4	-.1	-.5	.3	-.1	.0	.3	.3	.3	-.3	.9	.7	-.1	.3
46	-.3	.7	.5	.7	.6	.6	.2	.2	.6	.4	-.4	.7	.6	-.6	.0	.0	-.3	-.4	.1	-.1	-.3	.7
47	-.3	.7	.6	.5	.4	.3	.1	.1	.2	.2	-.2	.5	.3	-.2	-.1	.1	-.1	-.1	-.1	-.1	-.4	.0
48	-.2	.1	.3	.3	.3	.0	.3	.4	.3	.1	-.2	.4	-.1	.3	.4	.3	.5	-.3	.6	.4	.4	.2

	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1	.8	.6	.1	.0	.2	.3	.7	.7	-.1	.7	-.5	.7	-.2	.7	.6	.3	.6	.9	-.4	.5	.7	.6	-.3	-.3	-.3	-.2
2	-.5	-.6	.1	.6	.0	-.1	-.6	-.5	-.2	-.5	.6	-.7	.6	-.4	-.6	-.3	-.3	-.6	.2	-.5	-.3	-.5	.0	.4	.8	-.2
3	-.6	-.4	.3	.9	.0	-.2	-.6	-.7	-.2	-.4	.6	-.7	1.0	-.5	-.4	-.3	-.4	-.6	.4	-.2	-.3	-.4	.2	.3	.8	.1
4	.2	-.2	.2	.5	.0	.1	.0	-.2	.6	.3	-.3	.5	-.3	.1	.3	.0	-.2	-.3	.4	-.4	-.2	-.3	.7	.6	.7	.6
5	-.3	-.2	-.1	.5	.0	-.1	-.1	.0	.2	-.2	.0	.0	.8	-.3	-.2	-.1	-.3	-.3	.4	-.3	-.2	-.4	.5	.5	.7	.4
6	.0	-.2	-.2	.5	-.2	-.3	-.6	-.6	-.3	-.3	.4	-.3	.6	-.4	-.4	-.4	-.1	-.4	-.1	-.5	-.2	-.3	.1	.3	.8	-.3
7	.2	-.2	.4	.5	.1	.2	-.6	-.6	.4	.2	-.1	.3	-.1	.1	.3	.1	-.4	-.2	.4	-.5	-.4	-.3	.4	.4	.7	.6
8	.4	-.3	.2	.7	.0	.3	-.7	-.7	.4	-.1	-.3	.3	-.1	.4	.0	-.1	-.4	-.4	.7	-.6	-.2	-.4	.4	.3	.7	.8
9	-.5	-.3	.1	.4	.1	-.1	-.6	-.7	.2	-.6	.7	-.7	.6	-.2	-.4	-.3	-.5	-.7	.5	-.6	-.6	-.4	.3	.4	.7	.2
10	-.2	-.3	-.1	.4	.1	.0	-.7	-.7	-.4	-.4	.1	-.5	.6	-.3	-.4	-.4	-.6	-.6	.3	-.5	-.5	-.4	-.3	.4	.6	-.3
11	.5	.3	.3	-.2	.5	.5	.8	.7	-.2	.5	-.3	.5	-.2	.5	.5	.4	.7	.7	-.4	.6	.6	.6	-.3	-.3	-.4	-.5
12	-.3	-.2	.3	.4	-.1	-.4	-.7	-.6	.1	-.2	.3	-.3	.2	-.3	-.5	-.4	-.5	-.7	.5	-.6	-.5	-.3	.1	.4	.6	.1
13	-.4	-.3	-.1	.3	-.4	-.2	-.4	-.4	.0	-.3	.2	-.3	.2	-.2	-.4	-.1	-.4	-.4	.4	-.4	-.3	-.3	.0	.1	.6	-.1
14	.6	.7	.3	-.4	.4	.4	.7	.6	.0	.4	-.3	.6	-.4	.6	.4	.2	.4	.4	-.1	.3	.4	.6	.0	-.1	-.1	.2
15	.7	.5	.3	-.3	.3	.3	.6	.7	.1	.7	-.5	.6	-.5	.6	.6	.6	.2	.6	.4	.0	.5	.3	.3	.0	.2	.4
16	.3	-.1	.4	.0	.3	.4	.1	.1	.2	.3	-.1	.6	-.2	.5	.6	.5	.5	.3	.3	.0	.4	.2	.3	.1	.9	.3
17	.8	-.1	.4	.2	.3	.7	.6	.6	.0	.8	-.6	.9	-.4	.8	.8	.6	.7	.5	-.1	.5	.8	.6	.3	.0	.3	.3
18	.6	.6	.5	-.2	.8	.7	.5	.4	-.1	.4	-.3	.4	-.3	.4	.5	.5	.7	.4	-.6	.6	.6	.4	-.4	-.2	-.1	-.4
19	.7	-.2	.6	.6	.3	.6	.6	.6	.6	.7	-.5	.8	-.3	.8	.4	.4	-.4	.2	.6	-.6	-.1	-.1	.8	.4	.8	.9
20	.6	.1	.5	.2	.6	.7	.3	.1	.4	.5	-.4	.6	-.5	.6	.4	.3	.2	.3	.3	.0	.2	.2	.1	.0	.6	.5
21	.7	.3	.3	-.3	.2	.3	.5	.5	.0	.6	-.7	.7	-.4	.6	.6	.4	.5	.5	-.1	.3	.7	.6	-.2	-.1	.0	.1
22	.3	-.4	.2	.3	.1	.3	-.1	-.1	.6	.6	-.6	.6	-.4	.6	.6	.3	-.4	.1	.6	-.5	.1	-.2	.6	.6	.7	.6
23	.8	.5	.6	-.2	.3	.5	.7	.7	-.2	.8	-.6	.7	-.5	.7	.7	.5	.6	.6	-.1	.5	.7	.7	-.1	-.1	-.1	.0
24	.6	.9	.4	-.4	.4	.4	.6	.6	-.2	.4	-.3	.6	-.3	.4	.2	.2	.3	.8	-.4	.5	.3	.3	-.2	-.1	-.5	-.3
25	.8	.2	.9	-.1	.6	.8	.9	.8	.0	.7	-.7	.7	-.4	.7	.5	.3	.6	.9	-.3	.4	.7	.7	-.1	-.1	-.1	.1
26	.0	-.3	-.4	.9	-.2	-.3	-.7	-.7	-.3	-.2	.4	-.5	.7	.0	-.4	-.3	-.4	-.5	.4	-.7	-.4	-.3	.1	.4	.7	.3
27	.7	.4	.6	-.2	.9	.9	.7	.6	-.3	.6	-.4	.5	-.2	.7	.4	.4	.7	.7	-.7	.7	.7	.5	-.4	-.1	-.4	-.4
28	.7	.4	.7	-.2	.7	.9	.7	.7	-.1	.7	-.6	.6	-.4	.7	.6	.4	.7	.5	-.6	.6	.7	.4	-.3	-.3	-.1	.0
29	.7	.5	.3	-.3	.4	.5	.9	.8	-.5	.6	-.4	.6	-.5	.7	.4	.4	.4	.6	-.6	.5	.6	.7	-.4	-.1	-.5	-.3
30	.6	.3	.1	-.3	.4	.5	.7	.8	-.1	.7	-.7	.7	-.4	.6	.5	.4	.4	.8	-.2	.3	.3	.5	-.1	-.2	-.4	-.2
31	.3	-.2	.3	.2	-.1	.2	.1	.1	.9	.3	.1	.3	-.1	.1	-.2	-.3	-.8	-.2	.8	-.8	-.6	-.6	.8	.4	.5	.7
32	.7	.0	.6	-.4	.4	.6	.7	.7	-.1	.9	-.5	.8	-.4	.6	.7	.5	.7	.6	-.3	.6	.9	.7	-.3	.0	.0	.0
33	-.4	-.3	-.4	.4	-.3	-.5	-.7	-.6	-.1	-.6	.9	-.9	.7	-.6	-.7	-.6	-.7	-.7	.4	-.6	-.7	-.6	-.1	.3	.6	.1
34	.5	.4	.5	-.5	.2	.4	.6	.6	-.3	.7	-.7	.8	-.4	.6	.5	.5	.5	.6	-.2	.3	.5	.4	-.1	-.1	.1	.3
35	.1	-.2	-.1	.6	.0	-.2	-.8	-.8	-.3	-.6	.6	-.2	.9	-.5	-.4	-.4	-.6	-.7	.5	-.7	-.6	-.5	-.3	.1	.8	-.1
36	.6	.3	.4	-.4	.4	.4	.6	.5	-.3	.7	-.7	.9	-.2	.9	.4	.4	.6	.4	-.4	.4	.7	.6	-.1	-.2	-.2	.2
37	.7	.2	.4	.0	.3	.4	.4	.6	.0	.7	-.6	.9	-.3	.7	.9	.7	.6	.6	-.4	.6	.5	.6	-.3	.0	-.1	-.1
38	.5	.2	.4	.0	.1	.4	.5	.4	.0	.4	-.4	.5	-.2	.4	.7	.9	.3	.5	-.3	.4	.4	.5	-.3	-.1	-.1	-.3
39	.7	.3	.5	-.1	.5	.5	.5	.4	.0	.5	-.5	.7	-.3	.6	.6	.4	.9	.6	-.5	.8	.7	.7	-.5	-.4	-.5	-.4
40	.8	.4	.1	-.3	.3	.6	.7	.7	-.3	.6	-.6	.6	-.4	.6	.3	.4	.4	.7	-.4	.5	.4	.4	-.2	-.3	-.4	-.1
41	.2	-.3	.0	.1	-.4	-.3	-.1	-.2	.6	-.1	.3	-.2	.3	.0	-.4	-.3	-.7	-.4	.9	-.9	-.7	-.7	.7	.3	.6	.8
42	.6	.5	.4	-.3	.7	.6	.6	.6	-.2	.6	-.7	.6	-.4	.6	.5	.4	1.0	.7	-.5	.9	.8	.6	-.4	-.2	-.2	-.2
43	.7	.2	.4	-.1	.4	.4	.4	.5	-.2	.8	-.6	.7	-.4	.7	.5	.4	.7	.6	-.2	.5	.9	.7	-.1	-.1	.0	.0
44	.6	.4	.5	-.2	.5	.7	.9	.8	.1	.6	-.5	.6	-.2	.7	.4	.3	.3	1.0	.0	.6	.4	.7	.0	-.1	-.1	.1
45	.1	-.2	-.1	.3	-.3	.0	-.2	-.1	.9	.4	-.2	.4	.2	.1	.0	-.1	-.9	-.4	.8	-.8	-.5	-.5	.6	.3	.7	.7
46	-.3	-.2	.2	.7	.0	.0	-.8	-.7	.0	-.6	.5	-.4	.7	-.4	-.5	-.3	-.7	-.7	.4	-.7	-.7	-.6	.4	.9	.9	.3
47	-.6	-.3	-.1	.4	.0	-.3	-.4	-.3	.1	-.6	.7	-.8	.4	-.4	-.5	-.4	-.4	-.6	.5	-.4	-.6	-.4	.3	.4	.7	-.1
48	.6	-.1	.5	.0	.1	.4	.3	.4	.4	.7	-.7	.7	-.4	.4	.3	.3	-.2	.0	.0	-.3	-.3	.0	.4	.2	.7	.9

Table E2 – Standard deviation matrix using *linear* numeric equivalent.

Standard Desviation Matrix

Equivalent Numeric: Fixed (NC= .00 AM= 1.00 A = .67 AP= .33 DM= -1.00 D = -.67 DP= -.33) with Linear Ratio series.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1	.16	.47	.30	.55	.00	.38	.33	.33	.00	.34	.31	.00	.30	.20	.34	.49	.26	.77	.24	.33	.24	.00	.34	.46	.29	.00	.48	.34	.33	.35	.30	.33	.38	.26	.30	.31	.33	.33	.40	.15	.46	.38	.29	.40	.35	.40	.49	.50
2	.33	.17	.33	.37	.47	.34	.36	.36	.34	.35	.47	.24	.17	.54	.50	.33	.49	.60	.54	.39	.49	.34	.50	.46	.58	.37	.56	.63	.46	.41	.30	.47	.57	.29	.37	.53	.44	.55	.55	.46	.62	.58	.55	.50	.26	.37	.24	.55
3	.44	.40	.34	.40	.44	.40	.39	.37	.41	.39	.44	.42	.42	.40	.69	.60	.71	.62	.57	.49	.44	.53	.44	.49	.39	.24	.59	.65	.39	.42	.58	.46	.44	.41	.11	.47	.60	.55	.60	.46	.58	.61	.41	.46	.50	.34	.34	.67
4	.33	.37	.55	.34	.35	.61	.45	.33	.41	.34	.49	.35	.63	.64	.51	.40	.49	.40	.35	.37	.65	.24	.67	.30	.50	.41	.54	.58	.59	.56	.40	.62	.51	.58	.62	.65	.50	.55	.45	.51	.52	.55	.65	.39	.44	.36	.42	.42
5	.44	.35	.30	.62	.70	.53	.36	.11	.39	.29	.44	.41	.47	.46	.55	.30	.30	.44	.40	.24	.49	.50	.46	.34	.40	.44	.44	.33	.30	.49	.50	.50	.55	.61	.33	.40	.38	.30	.40	.40	.40	.41	.38	.46	.41	.41	.33	.39
6	.43	.41	.37	.50	.51	.34	.37	.15	.37	.41	.63	.55	.35	.46	.46	.30	.62	.54	.33	.33	.55	.26	.64	.34	.50	.44	.65	.68	.46	.48	.52	.61	.41	.68	.44	.50	.44	.40	.67	.49	.65	.58	.61	.46	.15	.55	.37	.50
7	.44	.44	.41	.35	.43	.55	.36	.33	.33	.24	.49	.24	.41	.43	.63	.30	.63	.49	.44	.39	.50	.42	.62	.37	.39	.38	.58	.71	.39	.44	.60	.55	.53	.50	.60	.71	.50	.64	.43	.63	.67	.41	.44	.46	.37	.37	.42	.39
8	.30	.41	.33	.35	.53	.53	.37	.34	.36	.53	.44	.35	.51	.57	.52	.33	.53	.64	.44	.42	.54	.60	.49	.40	.48	.46	.77	.78	.32	.43	.41	.55	.50	.49	.53	.55	.56	.47	.39	.44	.42	.44	.71	.46	.34	.29	.43	.24
9	.44	.24	.33	.36	.38	.28	.29	.29	.43	.28	.44	.36	.64	.68	.50	.40	.57	.61	.37	.33	.41	.38	.60	.33	.48	.55	.64	.65	.39	.41	.38	.44	.41	.42	.37	.67	.39	.39	.41	.43	.34	.36	.44	.49	.35	.40	.32	.58
10	.38	.31	.34	.33	.41	.34	.35	.30	.34	.34	.46	.40	.29	.47	.50	.40	.63	.53	.58	.50	.41	.41	.65	.39	.53	.55	.63	.74	.42	.32	.46	.43	.65	.41	.40	.65	.44	.44	.40	.46	.60	.41	.38	.46	.49	.35	.43	.50
11	.37	.48	.44	.44	.44	.38	.38	.38	.44	.44	.34	.38	.46	.34	.41	.37	.44	.35	.35	.35	.34	.38	.41	.39	.39	.38	.47	.41	.24	.41	.44	.44	.44	.41	.38	.44	.44	.44	.35	.43	.46	.44	.39	.44	.46	.40	.46	.47
12	.33	.24	.33	.37	.37	.31	.35	.29	.33	.38	.41	.34	.37	.41	.46	.49	.71	.55	.57	.53	.66	.38	.59	.58	.57	.54	.71	.66	.41	.44	.48	.63	.55	.64	.60	.74	.58	.55	.41	.42	.30	.44	.38	.41	.47	.31	.40	.62
13	.44	.43	.42	.33	.39	.31	.28	.33	.37	.38	.41	.41	.36	.53	.64	.34	.46	.52	.59	.58	.45	.24	.39	.42	.30	.37	.44	.50	.55	.59	.67	.52	.50	.57	.41	.58	.46	.40	.43	.43	.33	.43	.40	.41	.55	.16	.41	.44
14	.40	.43	.46	.34	.38	.22	.30	.40	.30	.49	.37	.37	.50	.34	.58	.40	.41	.34	.54	.33	.37	.46	.40	.42	.41	.46	.66	.66	.44	.42	.61	.49	.46	.48	.46	.46	.33	.34	.43	.64	.69	.33	.37	.44	.54	.22	.56	.50
15	.44	.38	.46	.38	.41	.40	.22	.22	.00	.24	.35	.40	.30	.41	.34	.50	.36	.77	.33	.56	.37	.22	.36	.44	.60	.41	.60	.62	.46	.44	.46	.37	.41	.42	.47	.43	.39	.44	.37	.40	.54	.60	.41	.34	.35	.26	.48	.37
16	.51	.49	.56	.44	.43	.37	.30	.30	.35	.00	.33	.63	.50	.65	.46	.42	.39	.29	.52	.30	.43	.22	.60	.56	.46	.54	.44	.49	.57	.57	.34	.63	.55	.39	.34	.47	.39	.38	.34	.47	.50	.42	.52	.34	.31	.47	.34	.44
17	.47	.46	.55	.41	.38	.15	.11	.00	.33	.22	.37	.58	.30	.41	.37	.44	.34	.43	.34	.37	.39	.22	.34	.47	.37	.47	.63	.26	.39	.39	.45	.24	.64	.33	.53	.33	.29	.46	.42	.50	.53	.38	.33	.44	.55	.42	.68	.52
18	.40	.41	.40	.34	.26	.22	.22	.22	.22	.26	.31	.49	.41	.30	.50	.35	.37	.34	.33	.50	.51	.00	.44	.37	.44	.44	.24	.41	.38	.40	.30	.39	.55	.40	.44	.37	.41	.38	.29	.44	.39	.36	.31	.33	.46	.44	.47	.35
19	.35	.42	.49	.50	.37	.44	.33	.60	.39	.36	.46	.55	.44	.43	.48	.49	.42	.66	.34	.36	.49	.44	.42	.41	.44	.40	.55	.42	.40	.40	.39	.35	.65	.37	.64	.24	.66	.43	.55	.58	.33	.44	.85	.65	.34	.37	.33	.24
20	.41	.36	.33	.24	.30	.33	.45	.29	.41	.40	.28	.55	.44	.44	.48	.35	.34	.41	.55	.34	.38	.28	.37	.37	.44	.30	.46	.41	.35	.50	.39	.34	.63	.35	.47	.41	.42	.47	.50	.43	.62	.51	.53	.29	.50	.26	.36	.56
21	.41	.41	.29	.00	.00	.00	.00	.00	.00	.00	.33	.42	.50	.44	.40	.40	.43	.59	.41	.33	.34	.22	.26	.50	.34	.49	.55	.41	.44	.44	.50	.40	.41	.41	.49	.39	.37	.40	.41	.44	.60	.51	.29	.39	.55	.22	.55	.41
22	.44	.61	.61	.34	.60	.71	.43	.39	.34	.51	.46	.50	.50	.55	.46	.37	.50	.41	.42	.48	.60	.34	.69	.46	.50	.68	.58	.61	.65	.65	.35	.20	.36	.31	.44	.37	.40	.47	.44	.77	.42	.41	.63	.50	.41	.46	.50	.39
23	.47	.40	.57	.26	.22	.22	.22	.22	.22	.34	.43	.41	.46	.44	.41	.41	.35	.46	.50	.56	.36	.56	.44	.44	.39	.44	.63	.69	.44	.44	.55	.37	.48	.43	.50	.32	.42	.47	.39	.43	.49	.41	.41	.41	.41	.22	.41	.39
24	.24	.46	.34	.33	.33	.33	.00	.00	.00	.33	.46	.47	.44	.46	.43	.60	.43	.42	.49	.55	.41	.00	.49	.34	.47	.49	.37	.37	.44	.44	.38	.43	.44	.47	.50	.46	.58	.58	.60	.33	.46	.41	.64	.63	.38	.22	.50	.40
25	.17	.48	.43	.46	.33	.36	.33	.00	.00	.42	.47	.44	.30	.41	.39	.44	.32	.44	.59	.34	.37	.30	.24	.55	.34	.55	.37	.17	.17	.34	.42	.35	.35	.31	.46	.33	.38	.37	.37	.17	.48	.39	.22	.32	.55	.30	.45	.40
26	.53	.56	.67	.66	.63	.44	.44	.36	.37	.41	.46	.41	.44	.46	.67	.56	.46	.81	.73	.49	.58	.38	.74	.60	.49	.34	.63	.68	.41	.41	.57	.50	.57	.58	.42	.66	.49	.40	.46	.50	.47	.33	.46	.50	.47	.46	.66	.46
27	.57	.55	.53	.53	.42	.44	.50	.50	.60	.33	.47	.66	.44	.50	.68	.49	.44	.15	.58	.34	.40	.38	.42	.39	.39	.80	.34	.24	.65	.69	.49	.40	.53	.69	.63	.42	.47	.47	.32	.42	.35	.35	.41	.69	.49	.55	.70	.49
28	.37	.53	.42	.53	.42	.42	.42	.42	.53	.42	.53	.60	.44	.53	.49	.47	.39	.41	.51	.38	.46	.39	.42	.39	.42	.63	.44	.34	.67	.67	.52	.33	.44	.46	.49	.41	.47	.47	.41	.67	.62	.42	.41	.66	.58	.40	.65	.61
29	.24	.44	.44	.44	.44	.44	.50	.50	.44	.44	.69	.44	.44	.48	.36	.46	.39	.36	.60	.49	.44	.33	.42	.44	.67	.50	.70	.67	.34	.37	.56	.42	.60	.39	.50	.44	.60	.44	.55	.40	.59	.47	.39	.41	.49	.30	.50	.39
30	.46	.50	.53	.44	.42	.33	.33	.44	.44	.44	.53	.44	.43	.48	.42	.49	.41	.44	.49	.29	.37	.33	.48	.44	.73	.46	.68	.67	.36	.34	.55	.33	.41	.22	.49	.42	.41	.40	.66	.24	.58	.44	.44	.38	.46	.38	.57	.53
31	.26	.46	.50	.51	.47	.24	.24	.24	.30	.47	.49	.33	.63	.47	.39	.63	.62	.49	.34	.34	.55	.42	.57	.38	.72	.58	.71	.78	.69	.70	.34	.61	.69	.49	.58	.65	.58	.50	.33	.55	.38	.44	.48	.47	.33	.39	.44	.41
32	.35	.42	.44	.38	.22	.22	.11	.11	.00	.22	.46	.39	.50	.39	.37	.47	.33	.43	.51	.24	.37	.22	.41	.42	.46	.46	.68	.39	.31	.31	.24	.34	.71	.17	.49	.39	.42	.47	.41	.40	.50	.46	.17	.32	.46	.42	.70	.66
33	.38	.42	.61	.34	.36	.36	.30	.30	.41	.41	.40	.30	.39	.53	.46	.46	.42	.55	.46	.50	.47	.33	.49	.46	.46	.60	.60	.50	.41	.44	.36	.48	.34	.24	.41	.49	.50	.53	.50	.44	.63	.53	.50	.53	.36	.40	.46	.22
34	.47	.38	.41	.38	.38	.50	.34	.00	.00	.33	.43	.48	.40	.47	.44	.46	.32	.43	.46	.37	.44	.33	.41	.40	.41	.47	.58	.44	.46	.46	.49	.50	.43	.34	.53	.46	.47	.47	.50	.47	.60	.64	.44	.46	.55	.55	.67	.41
35	.55	.38	.42	.41	.39	.41	.46	.37	.47	.62	.46	.31	.46	.50	.53	.47	.60	.55	.46	.41	.49	.50	.47	.38	.22	.48	.59	.55	.33	.33	.49	.42	.48	.75	.34	.65	.44	.44	.40	.42	.50	.29	.36	.41	.50	.53	.44	.55
36	.43	.51	.60	.44	.42	.55	.42	.42	.58	.42	.49	.68	.46	.49	.44	.46	.37	.64	.60	.39	.41	.38	.35	.34	.46	.49	.49	.68	.41	.47	.68	.37	.35	.17	.67	.34	.44	.44	.39	.41	.49	.43	.32	.37	.44	.44	.69	.30
37	.26	.22	.37	.22	.22	.22	.22	.22	.22	.22	.58	.33	.22	.30	.34	.37	.37	.40	.34	.34	.44	.22	.33	.37	.37	.00	.41	.39	.37	.29	.34	.31	.42	.17	.50	.26	.34	.36	.40	.41	.49	.40	.38	.42	.46	.34	.60	.49
38	.33	.22	.33	.38	.34	.11	.11	.11	.11	.34	.40	.44	.11	.33	.46	.40	.41	.40	.29	.22	.36	.00	.41	.56	.39	.00	.49	.39	.41	.39	.00	.41	.49	.50	.38	.47	.36	.34	.37	.38	.46	.39	.39	.44	.46	.22	.62	.46
39	.37	.33	.24	.24	.11	.11	.24	.24	.24	.11	.44	.37	.30	.47	.53	.34	.32	.17	.46	.30	.41	.33	.44	.41	.34	.33	.34	.30	.41	.44	.00	.41	.50	.33	.46	.41	.36	.44	.34	.39	.50	.24	.35	.41	.50	.49	.56	.49
40	.16	.46	.22	.11	.11	.11	.11	.11	.11	.11	.47	.50	.38	.44	.40	.41	.38	.41	.41	.33	.37	.33	.34	.33	.77	.50	.68	.46	.41	.41	.46	.44	.48	.44	.49	.44	.65	.44	.55	.36	.54	.50	.68	.50	.38	.46	.49	.47
41	.22	.40	.42	.42	.44	.51	.24	.17	.24	.44	.49	.60	.44	.46	.64	.49	.66	.50	.41	.35	.55	.34	.48	.40	.59	.52	.62	.63	.53	.58	.40	.55	.39	.63	.42	.70	.53	.50	.43	.49	.34	.34	.43	.50	.35	.36	.46	.34
42	.40	.38	.50	.44	.38	.33	.38	.44	.44	.38	.41	.44	.44	.49	.67	.46	.44	.33	.63	.53	.44	.44	.44	.41	.44	.60	.33	.40	.44	.44	.44	.43	.50	.40	.49	.43	.44	.47	.11	.36	.50	.34	.33	.46	.49	.63	.55	.50
43	.34	.26	.53	.38	.22	.22	.22	.11	.17	.11	.47	.49	.22	.46	.44	.47	.33	.47	.62	.55	.44	.33	.43	.56	.37	.34	.35	.24	.37	.34	.44	.17	.44	.36	.54	.31	.44	.39	.41	.39	.47	.47	.34	.41	.41	.41	.69	.56
44	.11	.49	.44	.44	.33	.33	.34	.34	.22	.11	.41	.50	.22	.44	.42	.39	.47	.42	.55	.34	.46	.00	.55	.47	.41	.44	.44	.22	.17	.33	.50	.44	.58	.46	.44	.41	.63	.39	.50	.11	.26	.31	.40	.43	.41	.55	.70	.69
45	.35	.50	.29	.35	.39	.30	.24	.33	.37	.36	.50	.44	.36	.35	.63	.39	.60	.57	.33	.33	.60	.36	.56	.38	.47	.55	.68	.66	.53	.58	.16	.35	.62	.60	.30	.70	.77	.60	.15	.57	.34	.33	.56	.56	.70	.37	.31	.42
46	.54	.36	.65	.41	.42	.40	.37	.37	.46	.41	.53	.43	.46	.44	.60	.56	.65	.49	.58	.50	.46	.43	.60	.55	.71	.60	.74	.78	.44	.50	.72	.46	.47	.48	.50	.67	.50	.46	.43	.50	.58	.41	.41	.40	.46	.34	.16	.52
47	.50	.41	.43	.50	.47	.44	.34	.24	.29	.30	.38	.47	.46	.38	.55	.53	.58	.53	.47	.60	.44	.00	.44	.60	.55	.47	.60	.46	.42	.44	.30	.42	.55	.33	.41	.68	.47	.46	.46	.48	.47	.44	.44	.49	.43	.46	.43	.55
48	.69	.56	.37	.44	.46	.44	.44	.42	.44	.24	.44	.42	.65	.66	.70	.65	.67	.69	.26	.41	.52	.62	.26	.30	.41	.61	.70	.67	.59	.33	.33	.33	.51	.41	.53	.68	.59	.36	.84	.70	.89	.78	.85	.71	.64	.62	.42	.34

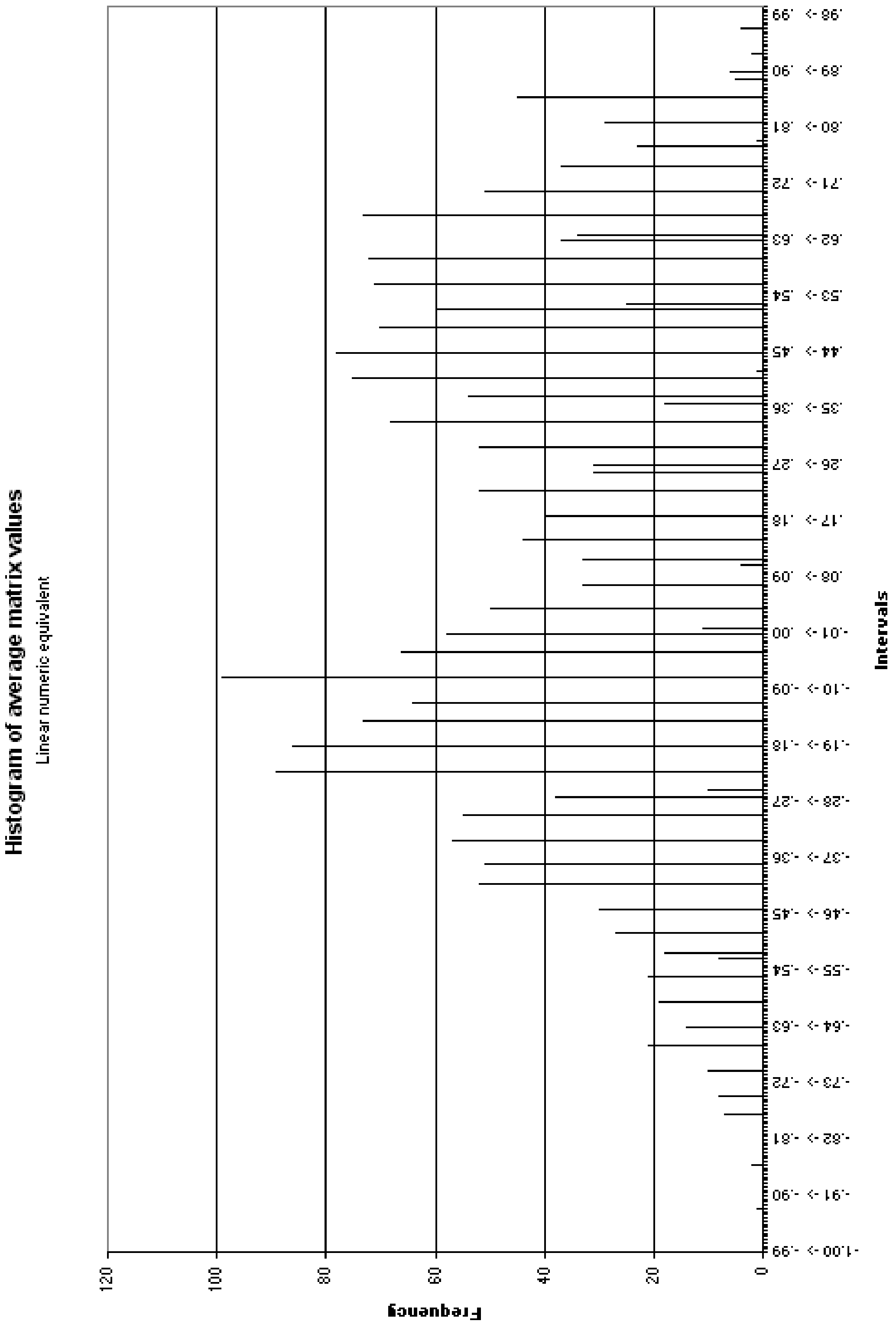

Figure E1 — Histogram of General Average Matrix values using *linear* numeric equivalent.

Table E3 – Energy of activation of each concept using *linear* numeric equivalent (increasing order).

Activation Energy

Ordered Answers Concerning Activation Energy

Numeric Equivalent: Linear Ratio series.

Concept	Activ.+	Concept	Activ.-	Concept	BeAct.+	Concept	BeAct.-
13 ==>	7.9	33 ==>	-13.9	8 ==>	6.9	33 ==>	-18.1
33 ==>	8.4	10 ==>	-12.4	7 ==>	7.2	42 ==>	-13.2
47 ==>	9.1	46 ==>	-12.4	10 ==>	8.0	35 ==>	-12.1
5 ==>	9.3	35 ==>	-12.0	33 ==>	8.4	39 ==>	-11.7
10 ==>	10.1	26 ==>	-11.8	22 ==>	8.6	29 ==>	-10.9
35 ==>	10.4	2 ==>	-11.1	6 ==>	8.6	41 ==>	-10.7
6 ==>	10.6	6 ==>	-11.0	35 ==>	9.4	40 ==>	-10.7
38 ==>	10.6	9 ==>	-10.8	31 ==>	9.4	30 ==>	-10.6
41 ==>	11.0	12 ==>	-10.8	46 ==>	9.8	43 ==>	-10.6
2 ==>	12.0	3 ==>	-10.7	13 ==>	9.9	44 ==>	-9.3
9 ==>	12.1	13 ==>	-10.2	45 ==>	10.3	37 ==>	-8.1
26 ==>	12.1	47 ==>	-10.1	24 ==>	10.5	45 ==>	-7.9
24 ==>	12.7	41 ==>	-9.5	5 ==>	10.6	34 ==>	-7.8
12 ==>	13.1	8 ==>	-8.3	11 ==>	11.7	11 ==>	-7.8
37 ==>	13.2	45 ==>	-8.3	4 ==>	11.7	19 ==>	-7.6
18 ==>	13.2	31 ==>	-8.1	3 ==>	11.8	47 ==>	-7.6
40 ==>	13.4	29 ==>	-7.9	9 ==>	11.9	14 ==>	-7.5
11 ==>	13.6	27 ==>	-7.2	19 ==>	12.1	24 ==>	-7.3
3 ==>	13.7	7 ==>	-7.1	2 ==>	12.2	31 ==>	-7.3
16 ==>	13.8	48 ==>	-7.0	26 ==>	12.4	2 ==>	-7.3
46 ==>	14.0	22 ==>	-6.8	42 ==>	13.1	26 ==>	-7.3
45 ==>	14.1	42 ==>	-6.6	16 ==>	13.2	48 ==>	-7.2
21 ==>	14.1	4 ==>	-6.5	48 ==>	13.3	18 ==>	-7.1
14 ==>	14.4	30 ==>	-6.4	14 ==>	13.8	36 ==>	-7.1
39 ==>	14.4	5 ==>	-6.4	38 ==>	13.8	13 ==>	-7.0
34 ==>	14.5	14 ==>	-5.8	12 ==>	13.9	27 ==>	-7.0
31 ==>	14.8	28 ==>	-5.8	41 ==>	14.0	32 ==>	-6.9
43 ==>	14.8	11 ==>	-5.7	44 ==>	14.8	28 ==>	-6.7
30 ==>	14.8	24 ==>	-5.7	20 ==>	14.9	12 ==>	-6.6
1 ==>	14.9	36 ==>	-5.6	39 ==>	15.5	3 ==>	-6.5
15 ==>	15.2	34 ==>	-5.5	18 ==>	15.7	38 ==>	-6.5
36 ==>	15.5	40 ==>	-5.3	1 ==>	16.2	23 ==>	-6.2
42 ==>	15.5	18 ==>	-5.3	15 ==>	16.4	17 ==>	-6.1
29 ==>	15.5	39 ==>	-5.1	21 ==>	16.7	21 ==>	-5.8
20 ==>	15.8	19 ==>	-4.9	27 ==>	16.7	15 ==>	-4.7
32 ==>	16.0	32 ==>	-4.8	25 ==>	16.7	4 ==>	-4.7
44 ==>	16.1	23 ==>	-4.8	43 ==>	17.0	46 ==>	-4.5
23 ==>	16.2	25 ==>	-4.5	40 ==>	17.5	1 ==>	-4.3
4 ==>	16.2	15 ==>	-4.4	37 ==>	17.5	6 ==>	-4.1
7 ==>	16.7	43 ==>	-4.3	30 ==>	17.5	10 ==>	-3.9
8 ==>	16.8	44 ==>	-4.1	29 ==>	17.9	25 ==>	-3.8
22 ==>	16.9	1 ==>	-3.8	28 ==>	19.8	20 ==>	-3.6
25 ==>	16.9	21 ==>	-3.8	32 ==>	20.1	16 ==>	-3.4
48 ==>	17.2	37 ==>	-3.7	47 ==>	20.2	22 ==>	-3.3
28 ==>	17.6	17 ==>	-3.6	17 ==>	21.0	5 ==>	-3.3
27 ==>	17.7	16 ==>	-3.5	36 ==>	21.4	7 ==>	-2.7
17 ==>	17.9	38 ==>	-3.2	23 ==>	22.1	9 ==>	-2.4
19 ==>	19.8	20 ==>	-2.9	34 ==>	22.6	8 ==>	-2.2

Table E4 – General Average Matrix using *golden ratio* numeric equivalent.

Average Matrix

Equivalent Numeric: Fixed (NC= .00 AM= 1.00 A = .85 AP= .62 DM= -1.00 D = -.85 DP= -.62) with Golden Ratio series.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.9	-.2	-.2	-.1	.0	-.2	.1	.1	.0	-.2	.8	.0	-.2	.9	.4	.1
2	-.1	.9	.7	.6	.5	.7	.3	.3	.9	.5	-.2	.9	.9	-.4	-.3	-.1
3	-.2	.7	.9	.7	.6	.5	.5	.6	.6	.7	-.4	.7	.7	-.3	-.1	.0
4	-.1	.7	.1	.9	.8	.0	.2	.4	.7	.3	-.2	.8	.2	-.1	.5	.1
5	-.2	.4	.7	.4	.6	.3	.0	.1	.4	.5	-.2	.4	.5	-.3	-.1	-.2
6	-.3	.7	.7	.3	.5	.9	.1	.1	.7	.7	-.1	.7	.8	-.6	-.3	-.2
7	-.2	.6	.5	.8	.5	.5	.8	.8	.8	.7	-.4	.9	.6	-.5	.1	-.2
8	-.2	.7	.8	.8	.4	.4	.7	.9	.8	.3	-.6	.8	.4	-.3	.1	-.1
9	-.2	.9	.5	.7	.6	.4	.3	.3	.8	.4	-.5	.8	.5	-.4	.3	-.1
10	-.2	.8	.6	.6	.6	.7	.4	.2	.6	.9	-.4	.7	.9	-.5	-.2	-.3
11	.8	-.4	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2	.9	-.2	-.4	.7	.4	.3
12	-.1	.9	.6	.7	.6	.5	.5	.5	.8	.6	-.4	.9	.7	-.6	.4	-.1
13	-.2	.5	.5	.4	.5	.4	.4	.4	.4	.6	-.4	.5	.8	-.4	-.3	-.3
14	.7	-.5	-.4	-.3	-.2	-.1	-.2	-.1	-.2	-.4	.6	-.3	-.3	.9	.2	.3
15	.5	-.2	.0	-.2	-.1	-.1	-.1	-.1	.0	-.2	.4	-.3	-.2	.4	.9	.5
16	.1	.0	.0	.2	.1	.1	-.2	-.2	.1	.0	.1	.1	.0	.1	.4	.7
17	.5	-.3	.1	-.1	-.2	.1	.1	.0	.1	-.1	.3	-.2	-.2	.4	.7	.6
18	.5	-.4	-.3	-.3	.0	-.1	-.1	-.1	-.1	.0	.8	-.1	-.4	.7	.0	.1
19	.1	.0	.1	.2	.3	.1	.7	.4	.4	.0	-.3	.1	-.2	.3	.6	.4
20	.1	.3	.4	.3	.2	.4	.3	.3	.2	.3	.1	.1	-.4	.6	.2	.4
21	.6	-.1	.0	.0	.0	.0	.0	.0	.0	.0	.5	.0	-.5	.6	.5	.5
22	.1	.1	.0	.9	.4	-.2	.5	.4	.9	.1	-.3	.4	.3	-.1	.4	.3
23	.6	-.3	-.3	.0	-.1	-.1	-.1	-.1	-.1	-.2	.5	-.1	-.3	.5	.5	.6
24	.9	-.6	-.2	-.1	-.1	-.1	.0	.0	.0	-.1	.5	-.5	-.4	.7	.5	.3
25	.9	-.4	-.3	-.3	-.1	.0	-.1	.0	.0	.0	.5	-.2	-.2	.4	.5	.5
26	-.1	.6	.7	.5	.5	.4	-.1	.0	.8	.5	-.3	.7	.6	-.6	-.2	.0
27	.7	-.2	-.2	-.2	.0	-.2	.0	.0	-.1	-.1	.6	-.1	-.2	.5	.3	.4
28	.8	-.1	.0	-.1	.0	.0	.0	.0	-.1	.0	.6	-.1	-.2	.6	.4	.5
29	.9	-.4	-.2	-.2	-.2	-.2	-.3	-.3	-.2	-.2	.5	-.2	-.2	.6	.7	.4
30	.7	-.3	-.4	-.2	.0	-.1	-.1	-.2	-.2	-.2	.6	-.2	-.3	.6	.7	.4
31	.0	.4	.2	.4	.5	.2	.2	.2	.3	-.2	-.4	.3	-.2	.5	.7	.2
32	.8	-.5	-.2	-.2	-.1	-.1	.1	.1	.0	-.1	.3	-.4	-.2	.4	.6	.5
33	-.2	.7	.5	.7	.3	.7	.3	.3	.6	.5	-.3	.7	.4	-.4	-.4	-.4
34	.5	-.2	-.4	-.2	-.2	-.3	-.2	.0	.0	-.1	.5	-.3	-.3	.5	.6	.6
35	-.1	.6	.7	.5	.5	.7	.3	.3	.5	.4	-.3	.8	.4	-.3	-.1	-.2
36	.7	-.1	-.2	-.1	.0	-.1	.0	.0	-.2	.0	.4	-.3	-.3	.4	.6	.4
37	.6	-.1	-.3	-.1	-.1	-.1	-.1	-.1	-.1	-.1	.2	-.3	-.1	.3	.3	.6
38	.6	-.1	-.1	-.2	-.2	-.1	-.1	-.1	-.1	-.2	.3	-.2	.1	.1	.4	.3
39	.7	-.4	-.2	-.2	-.1	-.1	-.2	-.2	-.2	-.1	.6	-.3	-.2	.5	.2	.4
40	.9	-.4	-.1	-.1	-.1	-.1	-.1	-.1	-.1	-.1	.5	-.3	-.2	.5	.5	.4
41	-.1	.3	.5	.4	.4	.1	.4	.3	.2	.1	-.4	.3	.6	-.4	.3	.1
42	.7	-.2	-.3	-.2	-.2	-.1	-.2	-.2	-.2	-.2	.7	-.2	-.2	.6	.1	.4
43	.6	.0	-.1	-.2	-.1	-.1	-.1	-.1	.0	-.1	.5	-.2	-.1	.4	.5	.5
44	1.0	-.4	-.2	-.2	-.1	-.1	.2	.2	-.1	-.1	.5	-.3	-.1	.4	.5	.4
45	.1	.3	.7	.5	.4	.3	.2	.4	.6	.0	-.5	.4	.0	.1	.4	.4
46	-.3	.8	.6	.7	.7	.7	.3	.3	.6	.5	-.4	.8	.6	-.6	.0	.0
47	-.3	.7	.7	.5	.5	.4	.2	.2	.3	.3	-.2	.6	.3	-.2	-.1	.1
48	-.2	.2	.4	.4	.3	.1	.4	.5	.4	.2	-.2	.5	-.1	.3	.4	.4

	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	.8	.4	.2	.4	.7	.0	.9	.6	.2	.0	.2	.4	.8	.8	-.2	.8
2	-.4	.0	.0	.5	-.2	.4	-.5	-.6	.2	.7	.1	-.1	-.6	-.6	-.3	-.5
3	-.2	.3	-.3	.0	-.2	.2	-.6	-.4	.4	.9	.1	-.2	-.7	-.7	-.3	-.4
4	.5	-.1	.8	.4	.1	.9	.3	-.3	.3	.6	.0	.1	-.1	-.3	.7	.3
5	-.3	-.1	-.1	.2	-.2	.3	-.3	-.3	-.1	.6	.1	-.1	-.2	-.1	.2	-.2
6	-.1	.0	-.1	-.1	-.2	.0	.0	-.3	-.2	.6	-.2	-.2	-.6	-.6	-.2	-.4
7	.4	.0	.6	.7	.3	.7	.3	-.3	.5	.6	.1	.2	-.7	-.6	.4	.3
8	.2	-.1	.6	.7	.5	.5	.5	-.3	.2	.7	.1	.3	-.8	-.8	.5	-.1
9	-.4	-.2	.0	.4	-.6	.6	-.5	-.4	.2	.5	.1	-.1	-.7	-.7	.2	-.6
10	-.4	-.1	-.2	-.5	-.4	.2	-.2	-.4	-.2	.5	.1	.0	-.7	-.8	-.4	-.5
11	.6	.8	-.1	.1	.6	-.2	.6	.4	.4	-.2	.5	.6	.9	.7	-.2	.6
12	-.2	-.2	.4	.2	.0	.6	-.3	-.3	.4	.5	-.1	-.4	-.7	-.6	.2	-.2
13	-.4	-.3	-.4	-.5	-.3	.2	-.5	-.4	-.2	.4	-.5	-.3	-.5	-.4	.1	-.3
14	.6	.7	.0	.7	.7	-.3	.7	.7	.4	-.4	.5	.5	.7	.7	.1	.4
15	.8	-.1	.5	.3	.7	-.1	.8	.6	.4	-.4	.4	.4	.6	.7	.2	.8
16	.7	.3	.3	.3	.5	-.1	.4	-.1	.4	.0	.4	.4	.1	.1	.2	.4
17	.9	.5	.7	.5	.7	.1	.9	-.1	.6	.2	.4	.8	.7	.7	.1	.9
18	.5	.9	-.1	.3	.4	.0	.6	.7	.6	-.2	.9	.7	.6	.5	-.2	.5
19	.7	.0	.9	.8	.6	.4	.7	-.2	.6	.7	.4	.7	.7	.7	.7	.8
20	.6	.7	.4	.9	.6	.1	.7	.2	.6	.3	.6	.7	.4	.2	.5	.6
21	.7	.4	.2	.4	.9	-.1	.8	.3	.4	-.2	.3	.4	.6	.6	.0	.7
22	.3	-.1	.7	.2	.0	.9	.3	-.4	.3	.3	.2	.4	-.1	-.1	.8	.8
23	.8	.4	.2	.3	.8	.0	.8	.6	.7	-.2	.4	.5	.7	.7	-.2	.8
24	.5	.7	-.2	.2	.5	.0	.6	.9	.5	-.4	.5	.5	.6	.6	-.2	.5
25	.8	.5	.1	.6	.7	-.2	.9	.2	.9	-.2	.7	.9	.9	.9	.0	.8
26	-.6	-.1	-.1	.0	-.1	.6	.0	-.3	-.4	.9	-.2	-.3	-.7	-.7	-.3	-.2
27	.6	1.0	-.3	.7	.7	-.2	.7	.5	.7	-.3	.9	.9	.7	.6	-.2	.7
28	.7	.7	.0	.6	.4	.0	.7	.5	.7	-.2	.7	.9	.7	.7	.0	.8
29	.7	.7	-.1	.1	.6	-.1	.7	.6	.4	-.3	.4	.6	.9	.8	-.5	.7
30	.7	.5	.0	.3	.6	-.1	.6	.4	.2	-.3	.4	.6	.8	.9	-.1	.8
31	.4	-.4	.9	.9	-.1	.5	.4	-.2	.3	.3	-.1	.3	.2	.0	.9	.4
32	.8	.5	.0	.3	.7	-.1	.7	.0	.6	-.4	.4	.7	.8	.8	-.2	.9
33	-.7	-.1	-.4	-.2	-.5	-.1	-.4	-.3	-.4	.4	-.3	-.5	-.7	-.6	.0	-.6
34	.8	.5	.1	.4	.6	-.1	.6	.5	.6	-.5	.3	.5	.6	.6	-.2	.7
35	-.2	-.2	-.4	-.1	-.4	.3	.1	-.2	-.1	.6	.1	-.2	-.8	-.8	-.2	-.7
36	.8	.3	.0	.5	.6	-.2	.8	.4	.4	-.4	.4	.4	.7	.6	-.3	.8
37	.7	.3	.0	.3	.6	-.1	.8	.3	.5	.0	.4	.5	.5	.7	.0	.8
38	.6	.3	.0	.1	.3	.0	.6	.3	.5	.0	.1	.5	.6	.5	.0	.5
39	.8	.9	-.3	.3	.6	-.1	.7	.4	.6	-.1	.7	.7	.6	.5	.0	.6
40	.6	.4	-.1	.4	.5	-.1	.9	.6	.2	-.3	.3	.6	.7	.7	-.3	.6
41	.1	-.5	.6	.5	.1	.2	.2	-.3	.1	.1	-.4	-.3	-.1	-.2	.7	-.1
42	.6	.8	-.4	.2	.6	-.2	.6	.6	.5	-.2	.8	.7	.6	.6	-.2	.7
43	.8	.6	-.2	.1	.6	-.1	.8	.3	.6	-.2	.5	.7	.5	.6	-.2	.9
44	.6	.4	.2	.6	.4	.0	.6	.5	.6	-.2	.6	.9	.9	.8	.2	.6
45	.4	-.2	.9	.8	.0	.3	.2	-.2	-.1	.4	-.3	.0	-.2	-.2	.9	.5
46	-.4	-.4	.2	-.1	-.3	.8	-.3	-.2	.2	.7	.0	.0	-.8	-.7	.1	-.6
47	-.2	-.1	-.1	.0	-.5	.0	-.6	-.3	-.1	.5	.0	-.3	-.5	-.4	.2	-.7
48	.6	-.3	.8	.5	.5	.3	.8	-.2	.6	.1	.1	.5	.4	.6	.6	.8

	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1	-.6	.8	-.3	.8	.7	.4	.7	1.0	-.4	.6	.8	.7	-.4	-.3	-.2	-.2
2	.6	-.8	.7	-.5	-.6	-.4	-.4	-.6	.3	-.5	-.4	-.5	.0	.6	.9	-.2
3	.6	-.7	1.0	-.5	-.4	-.4	-.4	-.6	.5	-.2	-.4	-.4	.3	.4	.9	.2
4	-.4	.5	-.2	.1	.4	-.1	-.3	-.4	.5	-.5	-.2	-.4	.7	.7	.7	.7
5	.1	.1	.8	-.3	-.2	-.2	-.3	-.3	.5	-.4	-.2	-.4	.6	.6	.8	.5
6	.5	-.3	.6	-.6	-.5	-.5	-.1	-.4	-.1	-.5	-.2	-.3	.1	.4	.8	-.3
7	-.2	.4	-.1	.1	.4	.1	-.5	-.2	.5	-.6	-.5	-.3	.6	.6	.7	.7
8	-.3	.4	-.1	.5	.0	-.1	-.5	-.5	.7	-.6	-.3	-.4	.6	.5	.8	.9
9	.7	-.7	.7	-.3	-.5	-.4	-.6	-.8	.7	-.7	-.6	-.4	.4	.5	.8	.3
10	.2	-.6	.7	-.4	-.5	-.5	-.7	-.6	.4	-.6	-.6	-.4	-.2	.5	.7	-.3
11	-.4	.6	-.2	.6	.6	.5	.8	.8	-.4	.6	.7	.6	-.3	-.3	-.4	-.5
12	.4	-.3	.3	-.3	-.5	-.5	-.6	-.7	.6	-.6	-.6	-.4	.1	.5	.7	.2
13	.3	-.3	.3	-.3	-.4	-.1	-.5	-.5	.6	-.5	-.3	-.4	.1	.2	.7	-.1
14	-.3	.6	-.4	.6	.6	.3	.5	.5	-.1	.4	.6	.6	.0	-.1	-.2	.2
15	-.6	.7	-.5	.7	.7	.6	.3	.7	.5	.0	.6	.4	.4	.0	.2	.5
16	-.1	.7	-.3	.5	.7	.6	.7	.4	.3	.0	.5	.3	.4	.1	.9	.4
17	-.6	.9	-.4	.8	.9	.6	.7	.5	-.1	.6	.8	.6	.3	.0	.2	.3
18	-.4	.5	-.4	.6	.6	.6	.8	.5	-.7	.7	.8	.5	-.4	-.2	-.1	-.5
19	-.6	.8	-.3	.9	.5	.5	-.5	.3	.7	-.6	.0	-.1	.9	.6	.8	.9
20	-.5	.8	-.5	.7	.5	.4	.3	.3	.3	.0	.3	.3	.1	.0	.7	.6
21	-.7	.7	-.4	.7	.7	.5	.6	.6	.0	.4	.8	.7	-.2	-.1	.1	.2
22	-.7	.8	-.5	.7	.7	.4	-.5	.1	.7	-.6	.1	-.2	.7	.6	.7	.7
23	-.6	.8	-.5	.8	.7	.5	.7	.7	.0	.6	.7	.7	-.1	-.1	-.1	.1
24	-.4	.6	-.3	.4	.3	.3	.4	.8	-.4	.6	.3	.4	-.2	-.1	-.5	-.3
25	-.8	.8	-.4	.8	.6	.4	.7	.9	-.3	.5	.9	.8	-.1	-.2	-.2	.1
26	.4	-.5	.7	.0	-.4	-.3	-.4	-.5	.5	-.8	-.4	-.3	.1	.4	.8	.3
27	-.5	.5	-.2	.7	.5	.5	.8	.7	-.8	.8	.7	.5	-.4	-.1	-.4	-.4
28	-.6	.6	-.4	.7	.6	.5	.7	.6	-.6	.7	.7	.5	-.3	-.3	-.1	.1
29	-.4	.7	-.5	.7	.4	.5	.5	.7	-.6	.5	.7	.7	-.4	-.2	-.5	-.4
30	-.7	.9	-.4	.7	.6	.5	.5	.9	-.2	.4	.4	.6	.0	-.2	-.4	-.2
31	.1	.4	-.2	.2	-.2	-.3	-.8	-.2	.8	-.8	-.6	-.6	.8	.5	.6	.7
32	-.5	.9	-.4	.7	.7	.5	.7	.7	-.3	.6	.9	.8	-.3	.0	.1	.0
33	.9	-.9	.7	-.6	-.7	-.6	-.7	-.7	.5	-.8	-.7	-.6	.0	.3	.6	.1
34	-.8	.9	-.4	.6	.5	.5	.5	.6	-.3	.3	.6	.5	-.1	-.1	.2	.4
35	.6	-.2	.9	-.6	-.5	-.5	-.7	-.7	.5	-.8	-.7	-.6	-.3	.1	.8	-.1
36	-.8	.9	-.2	.9	.5	.5	.7	.5	-.4	.5	.8	.7	-.1	-.2	-.2	.3
37	-.7	.9	-.3	.8	.9	.8	.7	.7	-.4	.7	.6	.7	-.3	.0	-.1	.0
38	-.4	.5	-.2	.5	.8	.9	.4	.6	-.3	.5	.5	.6	-.3	-.1	.0	-.3
39	-.5	.8	-.3	.7	.7	.8	.9	.7	-.5	.9	.8	.7	-.5	-.4	-.5	-.4
40	-.6	.6	-.4	.6	.4	.5	.5	.8	-.4	.5	.4	.5	-.2	-.3	-.4	-.1
41	.4	-.2	.4	.1	-.5	-.3	-.8	-.4	.9	-.9	-.8	-.7	.8	.3	.6	.9
42	-.7	.7	-.4	.7	.6	.5	1.0	.8	-.5	.9	.8	.6	-.4	-.2	-.2	-.2
43	-.6	.8	-.4	.8	.6	.5	.7	.7	-.2	.5	.9	.8	-.1	-.1	.0	.0
44	-.5	.6	-.2	.7	.5	.4	.4	1.0	.0	.8	.5	.8	.1	-.1	.0	.2
45	-.3	.5	.3	.1	.0	.0	-1.0	-.4	.9	-.8	-.5	-.5	.6	.4	.8	.7
46	.5	-.4	.7	-.5	-.5	-.3	-.8	-.7	.5	-.7	-.7	-.7	.4	.9	1.0	.3
47	.7	-.8	.5	-.4	-.5	-.4	-.4	-.6	.6	-.5	-.6	-.4	.3	.5	.8	-.1
48	-.7	.7	-.5	.4	.4	.3	-.1	.1	.0	-.3	-.2	.0	.5	.3	.7	.9

Table E5 – Standard deviation matrix using *golden ratio* numeric equivalent.

Standard Desviation Matrix

Equivalent Numeric: Fixed (NC= .00 AM= 1.00 A = .67 AP= .33 DM= -1.00 D = -.67 DP= -.33) with Linear Ratio series.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	.16	.47	.30	.55	.00	.38	.33	.33	.00	.34	.31	.00	.30	.20	.34	.49	.26	.77	.24	.33	.24	.00	.34	.46
2	.33	.17	.33	.37	.47	.34	.36	.36	.34	.35	.47	.24	.17	.54	.50	.33	.49	.60	.54	.39	.49	.34	.50	.46
3	.44	.40	.34	.40	.44	.40	.39	.37	.41	.39	.44	.42	.42	.40	.69	.60	.71	.62	.57	.49	.44	.53	.44	.49
4	.33	.37	.55	.34	.35	.61	.45	.33	.41	.34	.49	.35	.63	.64	.51	.40	.49	.40	.35	.37	.65	.24	.67	.30
5	.44	.35	.30	.62	.70	.53	.36	.11	.39	.29	.44	.41	.47	.46	.55	.30	.30	.44	.40	.24	.49	.50	.46	.34
6	.43	.41	.37	.50	.51	.34	.37	.15	.37	.41	.63	.55	.35	.46	.46	.30	.62	.54	.33	.33	.55	.26	.64	.34
7	.44	.44	.41	.35	.43	.55	.36	.33	.33	.24	.49	.24	.41	.43	.63	.30	.63	.49	.44	.39	.50	.42	.62	.37
8	.30	.41	.33	.35	.53	.53	.37	.34	.36	.53	.44	.35	.51	.57	.52	.33	.53	.64	.44	.42	.54	.60	.49	.40
9	.44	.24	.33	.36	.38	.28	.29	.29	.43	.28	.44	.36	.64	.68	.50	.40	.57	.61	.37	.33	.41	.38	.60	.33
10	.38	.31	.34	.33	.41	.34	.35	.30	.34	.34	.46	.40	.29	.47	.50	.40	.63	.53	.58	.50	.41	.41	.65	.39
11	.37	.48	.44	.44	.44	.38	.38	.38	.44	.44	.34	.38	.46	.34	.41	.37	.44	.35	.35	.35	.34	.38	.41	.39
12	.33	.24	.33	.37	.37	.31	.35	.29	.33	.38	.41	.34	.37	.41	.46	.49	.71	.55	.57	.53	.66	.38	.59	.58
13	.44	.43	.42	.33	.39	.31	.28	.33	.37	.38	.41	.41	.36	.53	.64	.34	.46	.52	.59	.58	.45	.24	.39	.42
14	.40	.43	.46	.34	.38	.22	.30	.40	.30	.49	.37	.37	.50	.34	.58	.40	.41	.34	.54	.33	.37	.46	.40	.42
15	.44	.38	.46	.38	.41	.40	.22	.22	.00	.24	.35	.40	.30	.41	.34	.50	.36	.77	.33	.56	.37	.22	.36	.44
16	.51	.49	.56	.44	.43	.37	.30	.30	.35	.00	.33	.63	.50	.65	.46	.42	.39	.29	.52	.30	.43	.22	.60	.56
17	.47	.46	.55	.41	.38	.15	.11	.00	.33	.22	.37	.58	.30	.41	.37	.44	.34	.43	.34	.37	.39	.22	.34	.47
18	.40	.41	.40	.34	.26	.22	.22	.22	.22	.26	.31	.49	.41	.30	.50	.35	.37	.34	.33	.50	.51	.00	.44	.37
19	.35	.42	.49	.50	.37	.44	.33	.60	.39	.36	.46	.55	.44	.43	.48	.49	.42	.66	.34	.36	.49	.44	.42	.41
20	.41	.36	.33	.24	.30	.33	.45	.29	.41	.40	.28	.55	.44	.44	.48	.35	.34	.41	.55	.34	.38	.28	.37	.37
21	.41	.41	.29	.00	.00	.00	.00	.00	.00	.00	.33	.42	.50	.44	.40	.40	.43	.59	.41	.33	.34	.22	.26	.50
22	.44	.61	.61	.34	.60	.71	.43	.39	.34	.51	.46	.50	.50	.55	.46	.37	.50	.41	.42	.48	.60	.34	.69	.46
23	.47	.40	.57	.26	.22	.22	.22	.22	.22	.34	.43	.41	.46	.44	.41	.41	.35	.46	.50	.56	.36	.56	.44	.44
24	.24	.46	.34	.33	.33	.33	.00	.00	.00	.33	.46	.47	.44	.46	.43	.60	.43	.42	.49	.55	.41	.00	.49	.34
25	.17	.48	.43	.46	.33	.36	.33	.00	.00	.42	.47	.44	.30	.41	.39	.44	.32	.44	.59	.34	.37	.30	.24	.55
26	.53	.56	.67	.66	.63	.44	.44	.36	.37	.41	.46	.41	.44	.46	.67	.56	.46	.81	.73	.49	.58	.38	.74	.60
27	.57	.55	.53	.53	.42	.44	.50	.50	.60	.33	.47	.66	.44	.50	.68	.49	.44	.15	.58	.34	.40	.38	.42	.39
28	.37	.53	.42	.53	.42	.42	.42	.42	.53	.42	.53	.60	.44	.53	.49	.47	.39	.41	.51	.38	.46	.39	.42	.39
29	.24	.44	.44	.44	.44	.44	.50	.50	.44	.44	.69	.44	.44	.48	.36	.46	.39	.36	.60	.49	.44	.33	.42	.44
30	.46	.50	.53	.44	.42	.33	.33	.44	.44	.44	.53	.44	.43	.48	.42	.49	.41	.44	.49	.29	.37	.33	.48	.44
31	.26	.46	.50	.51	.47	.24	.24	.24	.30	.47	.49	.33	.63	.47	.39	.63	.62	.49	.34	.34	.55	.42	.57	.38
32	.35	.42	.44	.38	.22	.22	.11	.11	.00	.22	.46	.39	.50	.39	.37	.47	.33	.43	.51	.24	.37	.22	.41	.42
33	.38	.42	.61	.34	.36	.36	.30	.30	.41	.41	.40	.30	.39	.53	.46	.46	.42	.55	.46	.50	.47	.33	.49	.46
34	.47	.38	.41	.38	.38	.50	.34	.00	.00	.33	.43	.48	.40	.47	.44	.46	.32	.43	.46	.37	.44	.33	.41	.40
35	.55	.38	.42	.41	.39	.41	.46	.37	.47	.62	.46	.31	.46	.50	.53	.47	.60	.55	.46	.41	.49	.50	.47	.38
36	.43	.51	.60	.44	.42	.55	.42	.42	.58	.42	.49	.68	.46	.49	.44	.46	.37	.64	.60	.39	.41	.38	.35	.34
37	.26	.22	.37	.22	.22	.22	.22	.22	.22	.22	.58	.33	.22	.30	.34	.37	.37	.40	.34	.34	.44	.22	.33	.37
38	.33	.22	.33	.38	.34	.11	.11	.11	.11	.34	.40	.44	.11	.33	.46	.40	.41	.40	.29	.22	.36	.00	.41	.56
39	.37	.33	.24	.24	.11	.11	.24	.24	.24	.11	.44	.37	.30	.47	.53	.34	.32	.17	.46	.30	.41	.33	.44	.41
40	.16	.46	.22	.11	.11	.11	.11	.11	.11	.11	.47	.50	.38	.44	.40	.41	.38	.41	.41	.33	.37	.33	.34	.33
41	.22	.40	.42	.42	.44	.51	.24	.17	.24	.44	.49	.60	.44	.46	.64	.49	.66	.50	.41	.35	.55	.34	.48	.40
42	.40	.38	.50	.44	.38	.33	.38	.44	.44	.38	.41	.44	.44	.49	.67	.46	.44	.33	.63	.53	.44	.44	.44	.41
43	.34	.26	.53	.38	.22	.22	.22	.11	.17	.11	.47	.49	.22	.46	.44	.47	.33	.47	.62	.55	.44	.33	.43	.56
44	.11	.49	.44	.44	.33	.33	.34	.34	.22	.11	.41	.50	.22	.44	.42	.39	.47	.42	.55	.34	.46	.00	.55	.47
45	.35	.50	.29	.35	.39	.30	.24	.33	.37	.36	.50	.44	.36	.35	.63	.39	.60	.57	.33	.33	.60	.36	.56	.38
46	.54	.36	.65	.41	.42	.40	.37	.37	.46	.41	.53	.43	.46	.44	.60	.56	.65	.49	.58	.50	.46	.43	.60	.55
47	.50	.41	.43	.50	.47	.44	.34	.24	.29	.30	.38	.47	.46	.38	.55	.53	.58	.53	.47	.60	.44	.00	.44	.60
48	.69	.56	.37	.44	.46	.44	.44	.42	.44	.24	.44	.42	.65	.66	.70	.65	.67	.69	.26	.41	.52	.62	.26	.30

	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1	.29	.00	.48	.34	.33	.35	.30	.33	.38	.26	.30	.31	.33	.33	.40	.15	.46	.38	.29	.40	.35	.40	.49	.50
2	.58	.37	.56	.63	.46	.41	.30	.47	.57	.29	.37	.53	.44	.55	.55	.46	.62	.58	.55	.50	.26	.37	.24	.55
3	.39	.24	.59	.65	.39	.42	.58	.46	.44	.41	.11	.47	.60	.55	.60	.46	.58	.61	.41	.46	.50	.34	.34	.67
4	.50	.41	.54	.58	.59	.56	.40	.62	.51	.58	.62	.65	.50	.55	.45	.51	.52	.55	.65	.39	.44	.36	.42	.42
5	.40	.44	.44	.33	.30	.49	.50	.50	.55	.61	.33	.40	.38	.30	.40	.40	.40	.41	.38	.46	.41	.41	.33	.39
6	.50	.44	.65	.68	.46	.48	.52	.61	.41	.68	.44	.50	.44	.40	.67	.49	.65	.58	.61	.46	.15	.55	.37	.50
7	.39	.38	.58	.71	.39	.44	.60	.55	.53	.50	.60	.71	.50	.64	.43	.63	.67	.41	.44	.46	.37	.37	.42	.39
8	.48	.46	.77	.78	.32	.43	.41	.55	.50	.49	.53	.55	.56	.47	.39	.44	.42	.44	.71	.46	.34	.29	.43	.24
9	.48	.55	.64	.65	.39	.41	.38	.44	.41	.42	.37	.67	.39	.39	.41	.43	.34	.36	.44	.49	.35	.40	.32	.58
10	.53	.55	.63	.74	.42	.32	.46	.43	.65	.41	.40	.65	.44	.44	.40	.46	.60	.41	.38	.46	.49	.35	.43	.50
11	.39	.38	.47	.41	.24	.41	.44	.44	.44	.41	.38	.44	.44	.44	.35	.43	.46	.44	.39	.44	.46	.40	.46	.47
12	.57	.54	.71	.66	.41	.44	.48	.63	.55	.64	.60	.74	.58	.55	.41	.42	.30	.44	.38	.41	.47	.31	.40	.62
13	.30	.37	.44	.50	.55	.59	.67	.52	.50	.57	.41	.58	.46	.40	.43	.43	.33	.43	.40	.41	.55	.16	.41	.44
14	.41	.46	.66	.66	.44	.42	.61	.49	.46	.48	.46	.46	.33	.34	.43	.64	.69	.33	.37	.44	.54	.22	.56	.50
15	.60	.41	.60	.62	.46	.44	.46	.37	.41	.42	.47	.43	.39	.44	.37	.40	.54	.60	.41	.34	.35	.26	.48	.37
16	.46	.54	.44	.49	.57	.57	.34	.63	.55	.39	.34	.47	.39	.38	.34	.47	.50	.42	.52	.34	.31	.47	.34	.44
17	.37	.47	.63	.26	.39	.39	.45	.24	.64	.33	.53	.33	.29	.46	.42	.50	.53	.38	.33	.44	.55	.42	.68	.52
18	.44	.44	.24	.41	.38	.40	.30	.39	.55	.40	.44	.37	.41	.38	.29	.44	.39	.36	.31	.33	.46	.44	.47	.35
19	.44	.40	.55	.42	.40	.40	.39	.35	.65	.37	.64	.24	.66	.43	.55	.58	.33	.44	.85	.65	.34	.37	.33	.24
20	.44	.30	.46	.41	.35	.50	.39	.34	.63	.35	.47	.41	.42	.47	.50	.43	.62	.51	.53	.29	.50	.26	.36	.56
21	.34	.49	.55	.41	.44	.44	.50	.40	.41	.41	.49	.39	.37	.40	.41	.44	.60	.51	.29	.39	.55	.22	.55	.41
22	.50	.68	.58	.61	.65	.65	.35	.20	.36	.31	.44	.37	.40	.47	.44	.77	.42	.41	.63	.50	.41	.46	.50	.39
23	.39	.44	.63	.69	.44	.44	.55	.37	.48	.43	.50	.32	.42	.47	.39	.43	.49	.41	.41	.41	.41	.22	.41	.39
24	.47	.49	.37	.37	.44	.44	.38	.43	.44	.47	.50	.46	.58	.58	.60	.33	.46	.41	.64	.63	.38	.22	.50	.40
25	.34	.55	.37	.17	.17	.34	.42	.35	.35	.31	.46	.33	.38	.37	.37	.17	.48	.39	.22	.32	.55	.30	.45	.40
26	.49	.34	.63	.68	.41	.41	.57	.50	.57	.58	.42	.66	.49	.40	.46	.50	.47	.33	.46	.50	.47	.46	.66	.46
27	.39	.80	.34	.24	.65	.69	.49	.40	.53	.69	.63	.42	.47	.47	.32	.42	.35	.35	.41	.69	.49	.55	.70	.49
28	.42	.63	.44	.34	.67	.67	.52	.33	.44	.46	.49	.41	.47	.47	.41	.67	.62	.42	.41	.66	.58	.40	.65	.61
29	.67	.50	.70	.67	.34	.37	.56	.42	.60	.39	.50	.44	.60	.44	.55	.40	.59	.47	.39	.41	.49	.30	.50	.39
30	.73	.46	.68	.67	.36	.34	.55	.33	.41	.22	.49	.42	.41	.40	.66	.24	.58	.44	.44	.38	.46	.38	.57	.53
31	.72	.58	.71	.78	.69	.70	.34	.61	.69	.49	.58	.65	.58	.50	.33	.55	.38	.44	.48	.47	.33	.39	.44	.41
32	.46	.46	.68	.39	.31	.31	.24	.34	.71	.17	.49	.39	.42	.47	.41	.40	.50	.46	.17	.32	.46	.42	.70	.66
33	.46	.60	.60	.50	.41	.44	.36	.48	.34	.24	.41	.49	.50	.53	.50	.44	.63	.53	.50	.53	.36	.40	.46	.22
34	.41	.47	.58	.44	.46	.46	.49	.50	.43	.34	.53	.46	.47	.47	.50	.47	.60	.64	.44	.46	.55	.55	.67	.41
35	.22	.48	.59	.55	.33	.33	.49	.42	.48	.75	.34	.65	.44	.44	.40	.42	.50	.29	.36	.41	.50	.53	.44	.55
36	.46	.49	.49	.68	.41	.47	.68	.37	.35	.17	.67	.34	.44	.44	.39	.41	.49	.43	.32	.37	.44	.44	.69	.30
37	.37	.00	.41	.39	.37	.29	.34	.31	.42	.17	.50	.26	.34	.36	.40	.41	.49	.40	.38	.42	.46	.34	.60	.49
38	.39	.00	.49	.39	.41	.39	.00	.41	.49	.50	.38	.47	.36	.34	.37	.38	.46	.39	.39	.44	.46	.22	.62	.46
39	.34	.33	.34	.30	.41	.44	.00	.41	.50	.33	.46	.41	.36	.44	.34	.39	.50	.24	.35	.41	.50	.49	.56	.49
40	.77	.50	.68	.46	.41	.41	.46	.44	.48	.44	.49	.44	.65	.44	.55	.36	.54	.50	.68	.50	.38	.46	.49	.47
41	.59	.52	.62	.63	.53	.58	.40	.55	.39	.63	.42	.70	.53	.50	.43	.49	.34	.34	.43	.50	.35	.36	.46	.34
42	.44	.60	.33	.40	.44	.44	.44	.43	.50	.40	.49	.43	.44	.47	.11	.36	.50	.34	.33	.46	.49	.63	.55	.50
43	.37	.34	.35	.24	.37	.34	.44	.17	.44	.36	.54	.31	.44	.39	.41	.39	.47	.47	.34	.41	.41	.41	.69	.56
44	.41	.44	.44	.22	.17	.33	.50	.44	.58	.46	.44	.41	.63	.39	.50	.11	.26	.31	.40	.43	.41	.55	.70	.69
45	.47	.55	.68	.66	.53	.58	.16	.35	.62	.60	.30	.70	.77	.60	.15	.57	.34	.33	.56	.56	.70	.37	.31	.42
46	.71	.60	.74	.78	.44	.50	.72	.46	.47	.48	.50	.67	.50	.46	.43	.50	.58	.41	.41	.40	.46	.34	.16	.52
47	.55	.47	.60	.46	.42	.44	.30	.42	.55	.33	.41	.68	.47	.46	.46	.48	.47	.44	.44	.49	.43	.46	.43	.55
48	.41	.61	.70	.67	.59	.33	.33	.33	.51	.41	.53	.68	.59	.36	.84	.70	.89	.78	.85	.71	.64	.62	.42	.34

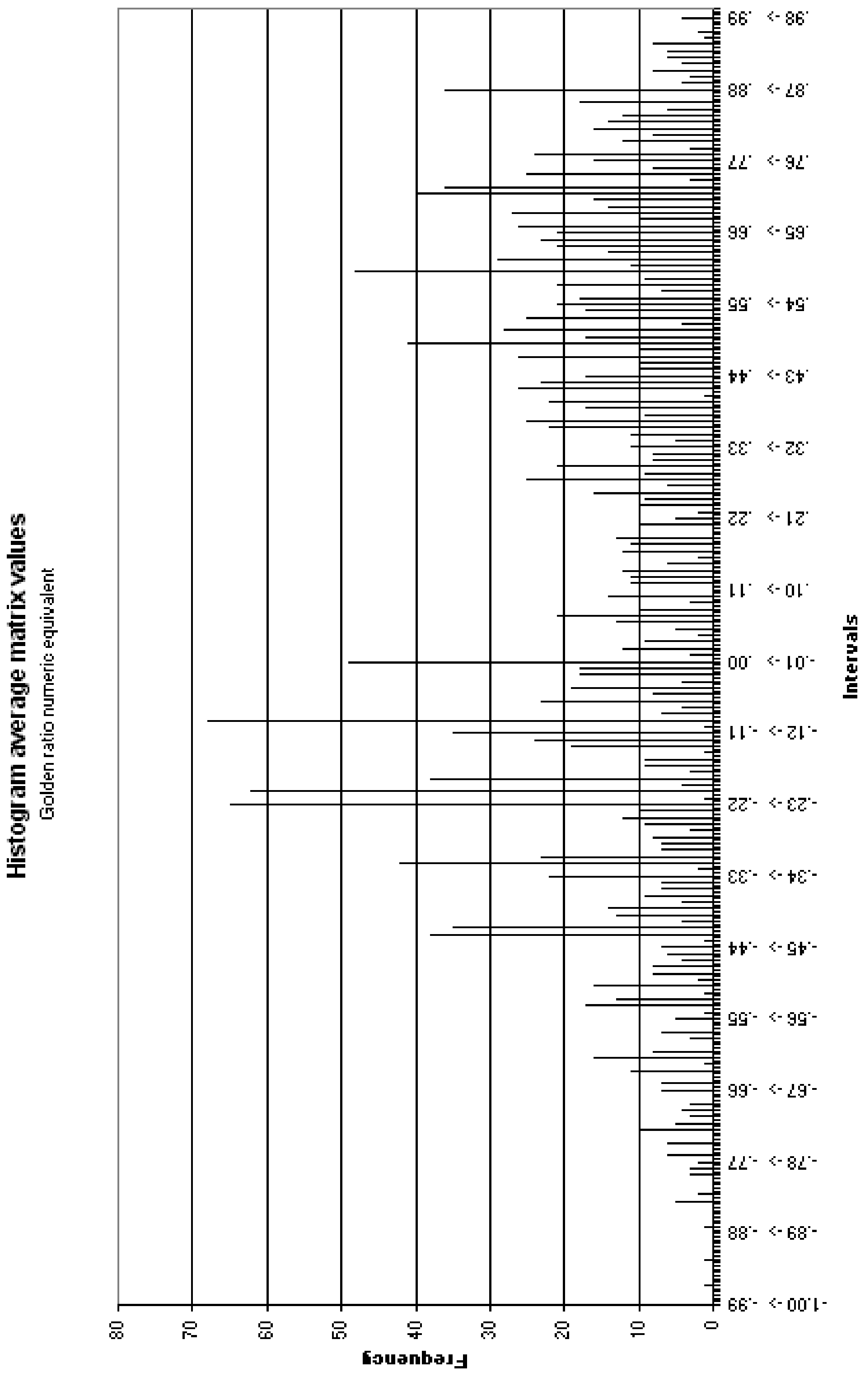

Figure E2 — Histogram of General Average Matrix values using *golden ratio* numeric equivalent.

Table E6 – Energy of activation of each concept using *golden ratio* numeric equivalent (increasing order).

```
                         Activation Energy
   Ordered Answers Concerning Activation Energy
   Numeric Equivalent: Golden Ratio      series.

 Concept Activ.+   Concept Activ.-   Concept BeAct.+   Concept BeAct.-
 ---------------------------------------------------------------------
    33 ==>   9.9      33 ==> -14.7       8 ==>   8.7      33 ==> -20.0
    13 ==>  10.1      10 ==> -14.0       7 ==>   9.2      42 ==> -14.8
    47 ==>  10.3      35 ==> -13.2      33 ==>   9.5      35 ==> -13.1
     5 ==>  11.4      46 ==> -13.2      10 ==>  10.2      39 ==> -13.1
    35 ==>  11.8      26 ==> -13.0      22 ==>  10.3      29 ==> -12.0
    10 ==>  12.2       6 ==> -12.5      35 ==>  10.6      43 ==> -11.8
    38 ==>  12.6       9 ==> -12.3       6 ==>  11.0      41 ==> -11.8
     6 ==>  12.8      12 ==> -12.3      13 ==>  11.3      30 ==> -11.7
    41 ==>  13.5       2 ==> -12.2      31 ==>  11.5      40 ==> -11.5
    26 ==>  13.7       3 ==> -11.9      46 ==>  11.8      44 ==> -10.1
     2 ==>  14.4      13 ==> -11.8       5 ==>  12.4      37 ==>  -8.9
    24 ==>  14.5      47 ==> -11.0      24 ==>  12.5      45 ==>  -8.7
     9 ==>  14.6      41 ==> -10.0      45 ==>  12.6      34 ==>  -8.7
    40 ==>  15.2       8 ==>  -9.5      11 ==>  13.3      24 ==>  -8.5
    46 ==>  15.4      45 ==>  -9.0       9 ==>  13.8      19 ==>  -8.4
     3 ==>  15.5      31 ==>  -8.8       4 ==>  14.0      11 ==>  -8.4
    11 ==>  15.6      29 ==>  -8.3       2 ==>  14.1      14 ==>  -8.3
    18 ==>  15.8       7 ==>  -8.1      26 ==>  14.2      47 ==>  -8.3
    37 ==>  15.9       4 ==>  -7.8       3 ==>  14.4       2 ==>  -8.2
    12 ==>  16.3      22 ==>  -7.8      19 ==>  14.7      36 ==>  -8.1
    16 ==>  16.4      27 ==>  -7.6      16 ==>  15.1      31 ==>  -8.1
    34 ==>  16.4      48 ==>  -7.3      42 ==>  15.2      48 ==>  -8.1
    14 ==>  16.6       5 ==>  -7.3      48 ==>  15.6      26 ==>  -8.0
    39 ==>  16.6      42 ==>  -6.9      14 ==>  15.6      13 ==>  -7.8
    21 ==>  17.0      30 ==>  -6.8      12 ==>  15.8      18 ==>  -7.8
    30 ==>  17.0      14 ==>  -6.6      38 ==>  16.2      32 ==>  -7.8
    31 ==>  17.1      18 ==>  -6.3      41 ==>  16.5      27 ==>  -7.6
    45 ==>  17.1      11 ==>  -6.2      44 ==>  16.9      38 ==>  -7.4
    42 ==>  17.2      36 ==>  -6.1      39 ==>  17.8      12 ==>  -7.3
    29 ==>  17.3      24 ==>  -6.1      18 ==>  18.4       3 ==>  -7.2
    43 ==>  17.3      28 ==>  -6.1      20 ==>  18.7      28 ==>  -7.2
    36 ==>  17.5      34 ==>  -6.0       1 ==>  18.7      23 ==>  -6.9
     1 ==>  17.8      40 ==>  -5.9      15 ==>  18.9      17 ==>  -6.8
    15 ==>  18.0      39 ==>  -5.8      27 ==>  19.5      21 ==>  -6.7
    32 ==>  18.2      32 ==>  -5.5      43 ==>  19.6      15 ==>  -5.3
    23 ==>  18.3      19 ==>  -5.3      40 ==>  19.6       4 ==>  -5.3
    44 ==>  18.7      23 ==>  -5.3      25 ==>  19.7      46 ==>  -5.2
     4 ==>  19.0      25 ==>  -5.1      30 ==>  19.8       1 ==>  -4.6
    25 ==>  19.3      15 ==>  -5.1      21 ==>  20.0       6 ==>  -4.5
    27 ==>  19.5      43 ==>  -4.8      37 ==>  20.3      10 ==>  -4.3
    20 ==>  19.6      44 ==>  -4.5      29 ==>  20.3      25 ==>  -4.3
     7 ==>  19.6       1 ==>  -4.4      47 ==>  22.4      16 ==>  -4.0
     8 ==>  19.6      37 ==>  -4.3      28 ==>  22.8      20 ==>  -3.9
    28 ==>  19.6      16 ==>  -4.3      32 ==>  23.3       5 ==>  -3.7
    22 ==>  19.8      21 ==>  -4.2      36 ==>  24.0      22 ==>  -3.7
    48 ==>  20.3      17 ==>  -4.0      17 ==>  24.1       7 ==>  -3.2
    17 ==>  20.5      38 ==>  -3.6      23 ==>  24.8       9 ==>  -2.8
    19 ==>  22.5      20 ==>  -3.6      34 ==>  25.5       8 ==>  -2.6
```

Table E7 – General Average Matrix using *reverse golden ratio* numeric equivalent.

[illegible]

Table E8 – Standard deviation matrix using *reverse golden ratio* numeric equivalent.

Standard Desviation Matrix

Equivalent Numeric: Fixed (NC= .00 AM= 1.00 A = .38 AP= .14 DM= -1.00 D = -.38 DP= -.14) with ReverseGold.Ratio series.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	.31	.45	.17	.52	.00	.34	.33	.33	.00	.33	.34	.00	.17	.30	.19	.40	.36	.73	.13	.18	.15	.00
2	.33	.33	.29	.40	.46	.30	.33	.33	.37	.32	.45	.33	.33	.50	.50	.18	.48	.44	.42	.33	.45	.19
3	.44	.42	.37	.42	.44	.22	.33	.32	.40	.40	.43	.45	.45	.34	.63	.51	.63	.60	.47	.39	.36	.42
4	.33	.37	.42	.39	.41	.44	.25	.18	.43	.18	.45	.41	.61	.55	.38	.23	.28	.23	.40	.33	.54	.36
5	.44	.20	.29	.60	.70	.43	.34	.05	.34	.17	.44	.34	.46	.44	.52	.17	.17	.36	.23	.13	.45	.41
6	.43	.44	.37	.38	.38	.39	.20	.06	.37	.44	.52	.51	.40	.47	.36	.17	.54	.42	.18	.18	.48	.14
7	.44	.45	.40	.40	.41	.46	.42	.38	.38	.15	.48	.36	.40	.41	.52	.17	.60	.39	.44	.40	.39	.45
8	.17	.43	.38	.41	.39	.43	.42	.37	.42	.43	.44	.41	.39	.47	.30	.18	.30	.55	.44	.45	.46	.55
9	.44	.36	.19	.36	.38	.16	.16	.16	.45	.16	.41	.42	.60	.66	.39	.23	.45	.43	.20	.18	.40	.38
10	.34	.36	.31	.31	.40	.30	.20	.17	.31	.39	.42	.42	.40	.47	.39	.34	.58	.40	.49	.46	.34	.23
11	.43	.49	.44	.44	.44	.34	.34	.34	.44	.44	.37	.34	.42	.30	.34	.34	.45	.40	.20	.20	.31	.34
12	.33	.37	.31	.37	.32	.18	.32	.17	.38	.38	.34	.37	.37	.40	.26	.40	.63	.40	.52	.42	.55	.38
13	.44	.41	.42	.18	.33	.18	.16	.18	.33	.39	.34	.40	.42	.53	.61	.19	.42	.39	.53	.50	.25	.13
14	.42	.41	.42	.19	.21	.13	.17	.23	.17	.48	.32	.34	.50	.37	.53	.34	.39	.30	.42	.36	.37	.44
15	.41	.34	.37	.34	.35	.23	.13	.13	.00	.13	.20	.34	.17	.34	.37	.50	.42	.66	.19	.44	.37	.13
16	.41	.39	.52	.37	.37	.20	.17	.17	.20	.00	.18	.52	.40	.61	.42	.45	.40	.16	.39	.17	.41	.13
17	.46	.44	.42	.35	.34	.06	.05	.00	.33	.13	.34	.53	.17	.34	.37	.44	.37	.41	.30	.32	.45	.13
18	.33	.34	.22	.19	.14	.13	.13	.13	.13	.14	.34	.40	.34	.29	.28	.20	.32	.37	.18	.39	.39	.00
19	.20	.37	.40	.41	.34	.38	.37	.53	.34	.34	.44	.52	.44	.43	.49	.48	.45	.55	.37	.42	.51	.43
20	.35	.33	.18	.13	.17	.18	.25	.16	.23	.34	.14	.42	.43	.46	.38	.32	.31	.43	.47	.37	.38	.14
21	.40	.35	.15	.00	.00	.00	.00	.00	.00	.00	.19	.37	.51	.45	.33	.33	.47	.53	.23	.18	.39	.13
22	.38	.54	.52	.39	.54	.63	.41	.34	.39	.41	.44	.38	.39	.42	.42	.34	.39	.35	.45	.38	.44	.37
23	.49	.34	.47	.14	.13	.13	.13	.13	.13	.33	.41	.35	.44	.41	.40	.40	.41	.42	.41	.44	.42	.52
24	.36	.47	.33	.33	.33	.33	.00	.00	.00	.33	.48	.47	.43	.49	.41	.53	.41	.45	.45	.52	.40	.00
25	.31	.49	.43	.44	.33	.34	.33	.00	.00	.37	.47	.44	.17	.34	.33	.41	.39	.41	.44	.31	.37	.17
26	.48	.49	.69	.65	.60	.43	.38	.34	.43	.40	.44	.43	.44	.47	.61	.52	.47	.74	.64	.39	.43	.39
27	.53	.48	.48	.48	.37	.44	.50	.50	.60	.33	.50	.62	.44	.50	.66	.48	.45	.27	.51	.30	.42	.34
28	.42	.48	.37	.48	.37	.37	.37	.37	.48	.37	.53	.60	.44	.53	.48	.46	.40	.43	.40	.38	.42	.35
29	.36	.43	.44	.44	.44	.44	.50	.50	.44	.44	.69	.44	.44	.49	.36	.42	.40	.36	.50	.40	.44	.33
30	.49	.50	.53	.44	.37	.33	.33	.44	.44	.44	.53	.44	.43	.49	.45	.48	.43	.41	.39	.16	.32	.33
31	.14	.42	.39	.39	.46	.13	.13	.13	.17	.45	.48	.32	.61	.46	.40	.61	.60	.48	.37	.39	.42	.42
32	.40	.42	.36	.34	.13	.13	.05	.05	.00	.13	.44	.34	.39	.34	.32	.46	.39	.41	.40	.13	.37	.13
33	.34	.45	.54	.30	.33	.36	.17	.17	.39	.40	.34	.29	.34	.53	.42	.42	.45	.49	.42	.39	.46	.33
34	.46	.34	.34	.34	.34	.50	.33	.00	.00	.33	.41	.44	.34	.46	.45	.47	.39	.41	.25	.33	.45	.33
35	.52	.38	.45	.40	.33	.44	.44	.34	.46	.60	.44	.41	.42	.50	.48	.45	.55	.48	.42	.35	.48	.39
36	.47	.50	.60	.38	.37	.52	.37	.37	.53	.37	.48	.66	.44	.48	.45	.42	.43	.61	.53	.33	.39	.34
37	.15	.13	.34	.13	.13	.13	.13	.13	.13	.13	.53	.32	.13	.17	.19	.32	.37	.34	.19	.19	.46	.13
38	.31	.13	.33	.34	.33	.05	.05	.05	.05	.33	.34	.44	.05	.18	.42	.34	.39	.34	.15	.13	.33	.00
39	.37	.18	.13	.13	.05	.05	.13	.13	.13	.05	.44	.34	.17	.47	.42	.19	.39	.33	.44	.17	.40	.33
40	.31	.42	.13	.05	.05	.05	.05	.05	.05	.05	.46	.50	.34	.41	.33	.34	.31	.34	.35	.18	.32	.33
41	.13	.34	.42	.43	.43	.50	.12	.07	.13	.38	.48	.53	.44	.42	.61	.40	.55	.50	.39	.32	.42	.33
42	.42	.34	.50	.44	.34	.33	.34	.44	.44	.34	.43	.44	.44	.51	.58	.42	.45	.39	.58	.42	.45	.44
43	.31	.14	.48	.34	.13	.13	.13	.05	.07	.05	.46	.45	.13	.42	.41	.46	.39	.49	.56	.42	.45	.33
44	.21	.48	.44	.44	.33	.33	.33	.33	.13	.05	.40	.50	.13	.43	.42	.34	.44	.34	.52	.31	.35	.00
45	.20	.39	.28	.32	.34	.17	.13	.18	.32	.34	.50	.35	.34	.20	.60	.34	.53	.53	.33	.38	.44	.33
46	.51	.42	.63	.43	.45	.42	.34	.34	.47	.40	.53	.45	.47	.44	.53	.52	.60	.48	.53	.46	.44	.45
47	.50	.43	.47	.50	.47	.43	.33	.13	.16	.17	.34	.50	.44	.34	.52	.48	.53	.48	.38	.51	.41	.00
48	.67	.52	.33	.43	.44	.38	.43	.42	.43	.13	.44	.42	.61	.66	.70	.60	.67	.57	.26	.40	.38	.60

	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1	.39	.47	.15	.00	.38	.19	.38	.41	.17	.38	.31	.36	.17	.36	.29	.18	.42	.27	.42	.38	.32	.42	.20	.34	.45	.39
2	.50	.47	.53	.37	.43	.52	.47	.39	.17	.46	.51	.32	.37	.48	.44	.47	.47	.47	.51	.50	.47	.50	.14	.32	.37	.48
3	.44	.48	.34	.33	.44	.52	.40	.45	.53	.42	.44	.43	.21	.46	.52	.47	.52	.47	.51	.43	.34	.42	.39	.19	.39	.56
4	.56	.17	.39	.40	.42	.43	.44	.44	.42	.44	.39	.50	.55	.53	.38	.42	.25	.39	.38	.45	.52	.34	.47	.36	.45	.45
5	.44	.19	.23	.45	.38	.18	.17	.40	.39	.39	.42	.54	.39	.34	.34	.17	.34	.34	.33	.34	.34	.42	.40	.39	.38	.33
6	.46	.19	.39	.45	.52	.58	.47	.49	.45	.54	.40	.57	.44	.37	.41	.33	.47	.48	.53	.50	.43	.44	.06	.47	.42	.44
7	.51	.34	.33	.38	.43	.63	.40	.44	.52	.44	.30	.38	.45	.55	.38	.55	.41	.61	.65	.39	.41	.44	.32	.32	.45	.40
8	.28	.34	.38	.48	.67	.73	.39	.45	.40	.42	.44	.28	.40	.45	.42	.26	.33	.41	.45	.44	.63	.42	.19	.17	.45	.36
9	.54	.18	.38	.46	.55	.53	.40	.43	.21	.44	.43	.45	.37	.56	.33	.34	.39	.45	.30	.36	.44	.48	.20	.33	.39	.53
10	.52	.34	.42	.46	.52	.65	.45	.39	.42	.41	.55	.40	.42	.60	.41	.41	.42	.47	.53	.40	.31	.42	.45	.32	.47	.44
11	.39	.34	.34	.34	.46	.39	.36	.43	.44	.45	.43	.40	.34	.45	.45	.41	.41	.45	.42	.44	.40	.44	.44	.34	.42	.46
12	.48	.53	.52	.46	.55	.58	.43	.44	.38	.51	.47	.51	.43	.69	.50	.46	.39	.45	.17	.44	.31	.34	.26	.18	.42	.54
13	.33	.34	.17	.33	.41	.39	.46	.53	.63	.39	.39	.47	.34	.53	.42	.23	.41	.41	.31	.41	.34	.34	.42	.07	.44	.36
14	.42	.45	.34	.42	.65	.65	.47	.45	.54	.48	.44	.49	.42	.47	.19	.19	.41	.60	.63	.18	.32	.44	.30	.13	.32	.39
15	.42	.45	.53	.34	.53	.60	.47	.47	.39	.43	.39	.45	.46	.47	.40	.44	.20	.42	.46	.44	.40	.19	.32	.14	.38	.32
16	.54	.49	.42	.42	.43	.48	.52	.52	.33	.60	.52	.40	.19	.46	.40	.38	.30	.26	.38	.24	.38	.19	.18	.38	.37	.43
17	.39	.26	.32	.45	.60	.36	.40	.40	.38	.36	.57	.33	.53	.39	.40	.47	.45	.51	.40	.31	.39	.44	.47	.37	.58	.39
18	.44	.37	.45	.44	.37	.43	.31	.33	.17	.33	.47	.33	.43	.32	.39	.31	.32	.41	.40	.36	.34	.19	.42	.44	.26	.20
19	.45	.35	.44	.42	.47	.45	.42	.42	.45	.41	.64	.42	.61	.37	.65	.41	.45	.53	.36	.44	.74	.53	.39	.32	.39	.33
20	.37	.20	.46	.17	.47	.43	.32	.41	.33	.31	.60	.40	.46	.44	.42	.43	.39	.35	.44	.40	.43	.16	.28	.14	.36	.49
21	.36	.38	.19	.45	.44	.34	.45	.45	.40	.42	.43	.43	.48	.40	.37	.33	.40	.46	.44	.39	.32	.40	.48	.13	.42	.23
22	.57	.42	.39	.67	.53	.54	.52	.52	.40	.25	.36	.34	.41	.42	.42	.26	.41	.66	.45	.39	.44	.39	.44	.47	.50	.40
23	.44	.45	.40	.36	.60	.68	.47	.47	.48	.42	.49	.45	.50	.39	.45	.46	.40	.47	.39	.40	.43	.43	.35	.13	.35	.21
24	.51	.37	.47	.48	.32	.32	.44	.44	.34	.41	.43	.49	.50	.42	.53	.53	.53	.39	.42	.40	.61	.60	.34	.13	.50	.34
25	.37	.48	.37	.52	.37	.33	.31	.39	.37	.41	.41	.36	.42	.38	.38	.33	.37	.31	.44	.33	.34	.39	.52	.17	.25	.23
26	.65	.53	.48	.37	.61	.66	.43	.43	.47	.39	.47	.50	.45	.55	.43	.34	.42	.50	.47	.38	.42	.50	.38	.42	.67	.44
27	.45	.33	.40	.78	.37	.36	.66	.70	.45	.42	.48	.68	.61	.45	.47	.47	.39	.45	.41	.41	.43	.68	.48	.52	.70	.48
28	.45	.33	.45	.61	.47	.37	.69	.69	.40	.38	.44	.47	.48	.43	.49	.47	.43	.67	.56	.45	.43	.65	.51	.34	.61	.54
29	.45	.45	.66	.50	.70	.67	.37	.42	.52	.45	.52	.40	.50	.47	.52	.41	.45	.42	.53	.41	.40	.43	.48	.17	.50	.34
30	.49	.43	.65	.44	.66	.67	.42	.39	.49	.38	.43	.34	.48	.45	.40	.33	.65	.37	.49	.35	.35	.38	.37	.34	.54	.46
31	.45	.34	.64	.53	.55	.73	.63	.64	.37	.54	.63	.28	.53	.55	.49	.44	.39	.48	.41	.44	.49	.49	.39	.33	.45	.43
32	.43	.37	.47	.42	.66	.40	.36	.36	.13	.37	.71	.33	.48	.40	.45	.46	.43	.42	.44	.47	.33	.39	.44	.37	.57	.55
33	.48	.44	.42	.52	.53	.50	.43	.44	.34	.49	.37	.36	.43	.51	.50	.53	.50	.47	.60	.53	.50	.53	.34	.34	.47	.13
34	.40	.33	.40	.46	.53	.41	.47	.47	.45	.50	.45	.39	.53	.47	.46	.46	.50	.49	.53	.61	.45	.48	.43	.52	.62	.42
35	.38	.34	.13	.49	.44	.48	.39	.39	.45	.45	.49	.69	.37	.63	.41	.41	.42	.45	.46	.32	.36	.40	.44	.48	.44	.52
36	.40	.19	.42	.48	.48	.66	.44	.50	.66	.43	.41	.33	.67	.37	.41	.41	.40	.40	.48	.41	.39	.37	.36	.44	.67	.17
37	.38	.20	.32	.00	.34	.33	.32	.28	.19	.36	.45	.33	.50	.36	.37	.42	.42	.44	.48	.42	.39	.45	.44	.19	.50	.39
38	.40	.44	.33	.00	.40	.33	.40	.33	.00	.40	.48	.50	.34	.47	.42	.37	.33	.38	.44	.33	.33	.45	.44	.13	.52	.44
39	.47	.34	.31	.33	.30	.17	.39	.41	.00	.39	.50	.38	.44	.44	.36	.41	.37	.40	.50	.37	.41	.43	.50	.48	.52	.48
40	.39	.19	.73	.50	.66	.47	.43	.43	.44	.44	.49	.44	.48	.44	.60	.41	.46	.42	.50	.50	.66	.48	.34	.44	.48	.38
41	.38	.34	.44	.50	.56	.55	.40	.49	.42	.41	.34	.61	.43	.64	.48	.44	.45	.48	.37	.37	.45	.50	.41	.33	.47	.39
42	.44	.40	.41	.55	.38	.42	.44	.44	.44	.47	.50	.42	.48	.47	.45	.47	.21	.42	.50	.37	.39	.47	.48	.61	.48	.39
43	.45	.44	.40	.33	.32	.15	.32	.31	.44	.33	.44	.42	.50	.36	.45	.33	.43	.40	.45	.46	.37	.47	.35	.35	.57	.52
44	.51	.47	.40	.44	.45	.34	.33	.39	.41	.38	.55	.43	.44	.43	.60	.34	.38	.21	.14	.34	.33	.45	.36	.52	.64	.63
45	.32	.34	.38	.44	.66	.55	.40	.43	.31	.32	.60	.53	.17	.57	.65	.51	.27	.50	.39	.39	.52	.52	.70	.33	.36	.45
46	.53	.48	.63	.53	.65	.73	.44	.50	.71	.47	.46	.43	.50	.65	.50	.44	.45	.50	.51	.43	.43	.42	.42	.37	.31	.39
47	.44	.53	.52	.47	.53	.44	.42	.43	.17	.45	.51	.39	.40	.66	.46	.42	.42	.49	.50	.41	.44	.48	.43	.48	.45	.52
48	.26	.17	.39	.54	.64	.65	.53	.31	.31	.38	.48	.43	.48	.66	.53	.33	.77	.64	.82	.73	.76	.64	.60	.60	.45	.37

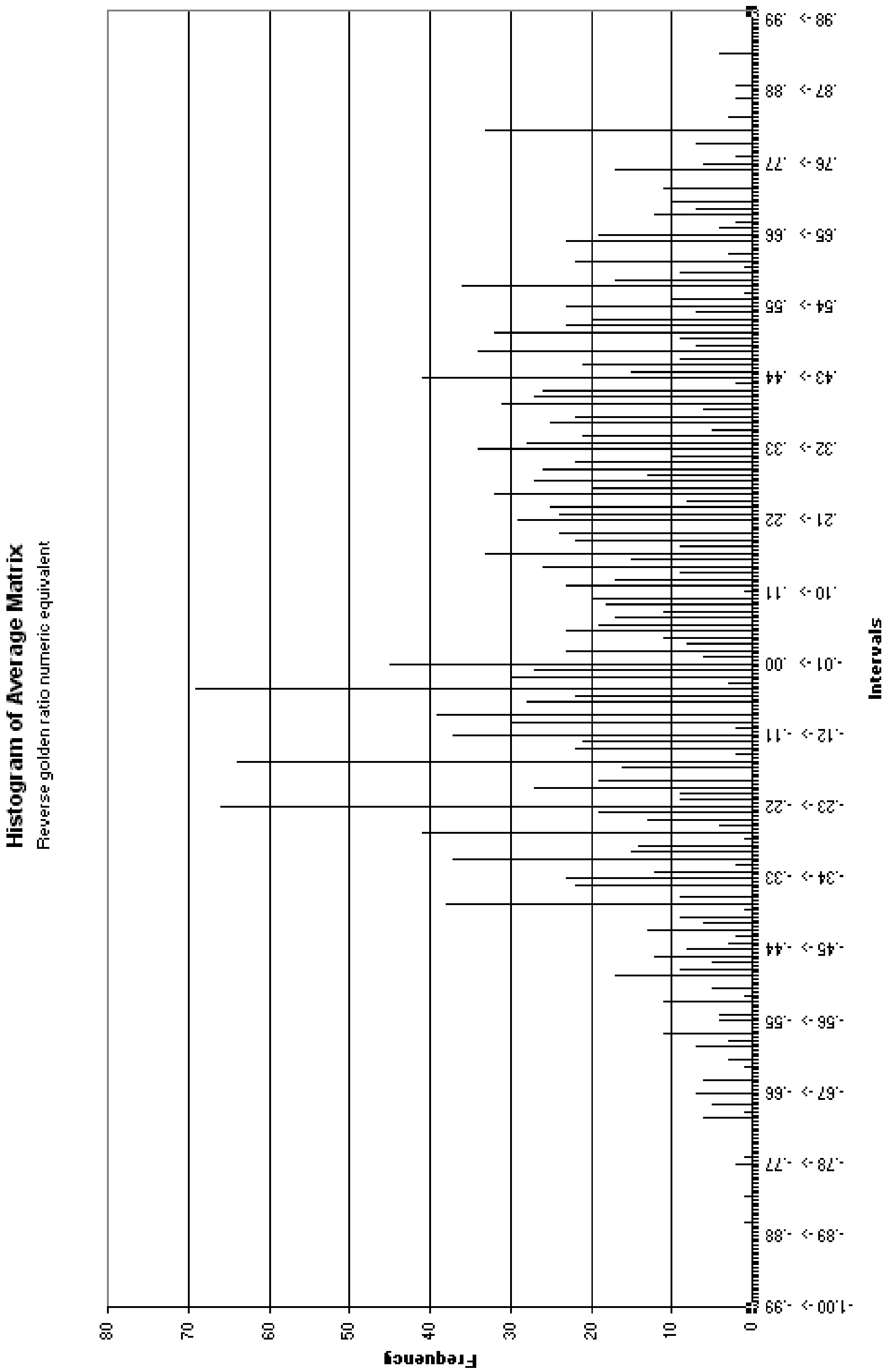

Figure E3— Histogram of General Average Matrix values using *reverse golden ratio* numeric equivalent.

Table E9 – Energy of activation of each concept using *reverse golden ratio* numeric equivalent (increasing order).

Activation Energy
Ordered Answers Concerning Activation Energy
Numeric Equivalent: *ReverseGold.Ratio* series.

Concept	Activ.+	Concept	Activ.-	Concept	BeAct.+	Concept	BeAct.-
13 ==>	5.5	33 ==>	-12.8	8 ==>	4.8	33 ==>	-15.5
33 ==>	6.4	46 ==>	-11.1	7 ==>	5.1	42 ==>	-10.8
5 ==>	6.8	35 ==>	-10.1	10 ==>	5.6	35 ==>	-10.6
10 ==>	7.6	26 ==>	-10.0	6 ==>	5.9	39 ==>	-9.8
47 ==>	7.8	10 ==>	-10.0	22 ==>	6.8	40 ==>	-9.6
6 ==>	7.9	2 ==>	-9.3	33 ==>	7.0	29 ==>	-9.2
38 ==>	8.0	3 ==>	-8.9	31 ==>	7.3	30 ==>	-9.1
41 ==>	8.4	6 ==>	-8.8	46 ==>	7.5	41 ==>	-9.1
35 ==>	8.7	9 ==>	-8.7	45 ==>	7.8	43 ==>	-8.8
9 ==>	8.9	41 ==>	-8.7	35 ==>	7.9	44 ==>	-8.1
2 ==>	9.2	47 ==>	-8.6	24 ==>	8.0	37 ==>	-6.9
12 ==>	9.2	12 ==>	-8.6	13 ==>	8.2	11 ==>	-6.8
18 ==>	9.7	13 ==>	-7.9	5 ==>	8.2	45 ==>	-6.6
37 ==>	9.9	29 ==>	-7.3	3 ==>	8.7	34 ==>	-6.5
26 ==>	10.2	45 ==>	-7.3	19 ==>	8.9	14 ==>	-6.5
45 ==>	10.4	31 ==>	-7.2	4 ==>	9.1	47 ==>	-6.5
21 ==>	10.4	27 ==>	-6.5	11 ==>	9.6	26 ==>	-6.3
16 ==>	10.5	48 ==>	-6.5	9 ==>	9.6	19 ==>	-6.2
24 ==>	10.6	8 ==>	-6.5	2 ==>	9.8	31 ==>	-6.2
40 ==>	10.9	42 ==>	-6.2	42 ==>	10.2	2 ==>	-6.2
11 ==>	11.0	30 ==>	-6.0	26 ==>	10.4	27 ==>	-6.1
3 ==>	11.0	7 ==>	-5.4	20 ==>	10.4	18 ==>	-6.0
39 ==>	11.2	28 ==>	-5.3	48 ==>	10.6	13 ==>	-5.9
1 ==>	11.2	22 ==>	-5.3	16 ==>	10.7	28 ==>	-5.9
14 ==>	11.3	24 ==>	-5.1	38 ==>	10.8	48 ==>	-5.7
20 ==>	11.5	5 ==>	-5.0	41 ==>	11.1	32 ==>	-5.7
43 ==>	11.8	11 ==>	-4.9	14 ==>	11.5	24 ==>	-5.7
31 ==>	11.8	36 ==>	-4.9	12 ==>	11.7	36 ==>	-5.7
15 ==>	11.9	40 ==>	-4.7	44 ==>	12.0	12 ==>	-5.6
46 ==>	12.1	34 ==>	-4.7	18 ==>	12.3	3 ==>	-5.6
30 ==>	12.2	4 ==>	-4.6	39 ==>	12.4	17 ==>	-5.1
34 ==>	12.2	14 ==>	-4.5	21 ==>	12.6	38 ==>	-5.1
4 ==>	12.4	39 ==>	-4.3	15 ==>	12.9	23 ==>	-5.1
36 ==>	12.9	19 ==>	-4.2	25 ==>	12.9	21 ==>	-4.6
7 ==>	13.0	23 ==>	-4.0	27 ==>	13.0	4 ==>	-3.9
44 ==>	13.0	32 ==>	-3.9	43 ==>	13.3	1 ==>	-3.9
29 ==>	13.1	18 ==>	-3.7	1 ==>	13.4	15 ==>	-3.8
32 ==>	13.1	44 ==>	-3.7	37 ==>	13.8	46 ==>	-3.5
8 ==>	13.1	25 ==>	-3.7	30 ==>	14.5	6 ==>	-3.4
42 ==>	13.3	43 ==>	-3.7	29 ==>	14.7	10 ==>	-3.4
22 ==>	13.3	15 ==>	-3.3	40 ==>	14.7	25 ==>	-3.1
48 ==>	13.5	21 ==>	-3.2	28 ==>	15.7	20 ==>	-3.1
23 ==>	13.6	37 ==>	-2.9	32 ==>	15.9	22 ==>	-2.8
25 ==>	13.6	17 ==>	-2.9	17 ==>	16.9	5 ==>	-2.7
17 ==>	14.7	1 ==>	-2.9	47 ==>	17.4	16 ==>	-2.4
28 ==>	15.1	38 ==>	-2.7	36 ==>	17.8	7 ==>	-2.0
27 ==>	15.4	16 ==>	-2.5	23 ==>	18.3	9 ==>	-2.0
19 ==>	16.5	20 ==>	-2.1	34 ==>	18.5	8 ==>	-1.8

Table E10 – General Average Matrix using *square ratio* numeric equivalent.

Average Matrix

Equivalent Numeric: Fixed (NC= .00 AM= 1.00 A = .50 AP= .25 DM= -1.00 D = -.50 DP= -.25) with Square Ratio series.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1	.7	-.2	-.1	-.1	.0	-.2	.1	.1	.0	-.1	.5	.0	-.1	.6	.3	.0	.6	.2	.1	.2	.4	.0	.8	.6	.1	.0	.2	.3	.6	.6	-.1	.6	-.4	.6	-.1	.6	.4	.2	.5	.9	-.3	.4	.6	.5	-.2	-.2	-.3	-.2
2	-.1	.8	.4	.4	.4	.4	.2	.2	.8	.3	-.2	.9	.8	-.4	-.3	-.1	-.4	-.1	-.1	.3	-.3	.3	-.5	-.6	.1	.5	.0	-.2	-.6	-.4	-.1	-.4	.6	-.6	.5	-.4	-.5	-.3	-.3	-.6	.2	-.4	-.3	-.5	.0	.4	.8	-.2
3	-.2	.5	.8	.5	.5	.3	.3	.4	.4	.6	-.3	.7	.7	-.2	-.1	.1	-.2	.2	-.3	-.1	-.2	.1	-.5	-.4	.3	.9	.0	-.2	-.6	-.7	-.1	-.3	.5	-.6	.9	-.4	-.4	-.3	-.4	-.6	.4	-.2	-.3	-.3	.2	.3	.8	.1
4	-.1	.5	.1	.8	.6	-.1	.1	.2	.6	.1	-.3	.6	.2	-.1	.3	.1	.3	-.1	.6	.3	-.1	.8	.1	-.1	.2	.4	-.1	.1	.0	-.1	.5	.2	-.3	.4	-.3	.1	.3	.0	-.1	-.3	.3	-.4	-.2	-.3	.6	.5	.7	.6
5	-.2	.2	.4	.3	.6	.1	-.1	.0	.3	.3	-.2	.3	.4	-.3	-.1	-.1	-.1	-.1	-.1	.1	-.3	.1	-.3	-.2	-.1	.5	.0	-.1	-.1	.0	.2	-.2	.0	.0	.7	-.2	-.2	-.1	-.2	-.2	.3	-.3	-.2	-.3	.4	.4	.6	.3
6	-.3	.5	.5	.2	.3	.8	.1	.1	.5	.5	-.2	.6	.6	-.6	-.3	-.1	-.1	-.1	-.1	-.1	-.2	.0	-.1	-.2	-.2	.5	-.2	-.3	-.6	-.6	-.3	-.2	.4	-.3	.5	-.4	-.4	-.3	-.1	-.4	-.1	-.4	-.2	-.3	.1	.3	.8	-.3
7	-.2	.5	.4	.6	.4	.4	.7	.6	.6	.3	-.4	.8	.4	-.4	.2	-.1	.3	-.1	.5	.6	.2	.6	.2	-.2	.3	.4	.1	.2	-.6	-.5	.4	.1	-.1	.3	-.1	.2	.3	.1	-.4	-.2	.4	-.4	-.4	-.3	.4	.4	.7	.6
8	-.1	.6	.6	.6	.3	.1	.5	.8	.7	.1	-.5	.6	.3	-.3	.1	-.1	.1	-.1	.5	.7	.3	.5	.3	-.2	.2	.7	.0	.3	-.7	-.7	.4	-.1	-.3	.2	-.1	.4	-.1	-.1	-.3	-.4	.7	-.5	-.2	-.3	.3	.3	.7	.7
9	-.2	.8	.3	.5	.4	.2	.2	.2	.7	.2	-.4	.7	.3	-.3	.2	-.1	-.2	-.2	.0	.2	-.4	.4	-.5	-.2	.1	.4	.1	-.1	-.6	-.6	.1	-.5	.6	-.7	.5	-.1	-.3	-.3	-.4	-.7	.4	-.5	-.5	-.4	.2	.3	.7	.1
10	-.2	.6	.4	.4	.4	.4	.2	.1	.4	.8	-.3	.5	.7	-.4	-.2	-.2	-.4	-.1	-.2	-.5	-.3	.1	-.2	-.3	-.1	.4	.2	.1	-.7	-.7	-.3	-.4	.1	-.4	.5	-.3	-.4	-.4	-.5	-.6	.2	-.4	-.4	-.3	-.3	.3	.6	-.3
11	.6	-.4	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2	.8	-.2	-.3	.4	.3	.2	.5	.6	.0	.0	.4	-.2	.4	.3	.3	-.2	.4	.4	.7	.6	-.2	.5	-.3	.4	-.2	.5	.5	.4	.6	.7	-.3	.5	.6	.5	-.3	-.2	-.3	-.4
12	-.1	.8	.4	.5	.4	.3	.3	.3	.6	.4	-.3	.8	.5	-.4	.2	.0	-.2	-.2	.2	.1	.0	.4	-.3	-.1	.2	.3	-.2	-.4	-.6	-.5	.1	-.2	.3	-.3	.2	-.3	-.4	-.4	-.4	-.7	.4	-.5	-.4	-.3	.1	.3	.5	.1
13	-.2	.4	.3	.2	.3	.2	.2	.2	.3	.4	-.3	.4	.7	-.4	-.2	-.2	-.3	-.2	-.4	-.4	-.1	.1	-.3	-.3	-.1	.3	-.4	-.2	-.4	-.4	.0	-.2	.2	-.3	.2	-.2	-.3	-.1	-.4	-.4	.4	-.4	-.2	-.3	.0	.1	.5	-.1
14	.5	-.4	-.3	-.2	-.1	-.1	-.1	-.1	-.1	-.4	.4	-.2	-.3	.8	.1	.2	.4	.4	.1	.5	.5	-.3	.5	.7	.3	-.3	.4	.4	.6	.6	.0	.4	-.3	.6	-.3	.6	.3	.2	.4	.3	-.1	.2	.4	.5	.0	-.1	-.1	.2
15	.4	-.2	-.1	-.2	-.1	-.1	-.1	-.1	.0	-.1	.2	-.2	-.1	.3	.8	.5	.7	-.1	.3	.1	.5	-.1	.7	.5	.2	-.3	.2	.3	.6	.6	.0	.6	-.4	.6	-.4	.6	.6	.5	.2	.5	.3	.0	.4	.3	.3	.0	.2	.3
16	.0	-.1	.0	.1	.1	.1	-.1	-.1	.0	.0	.1	.2	.0	.1	.3	.7	.6	.2	.2	.1	.4	-.1	.3	-.2	.3	.1	.3	.4	.1	.1	.2	.3	-.1	.6	-.2	.4	.6	.4	.4	.2	.2	.0	.3	.2	.2	.1	.8	.3
17	.4	-.3	.0	-.1	-.2	.1	.0	.0	.1	-.1	.2	-.1	-.1	.3	.5	.5	.8	.4	.4	.3	.6	.1	.8	-.1	.4	.2	.3	.6	.6	.6	.0	.7	-.6	.9	-.4	.7	.7	.6	.7	.5	-.1	.4	.7	.5	.3	.1	.3	.2
18	.3	-.3	-.2	-.2	.0	-.1	-.1	-.1	-.1	.0	.5	.0	-.3	.4	.0	.0	.3	.8	-.1	.2	.3	.0	.5	.5	.5	-.2	.8	.6	.4	.3	-.1	.3	-.3	.3	-.3	.4	.4	.4	.6	.4	-.6	.5	.5	.3	-.3	-.2	-.1	-.3
19	.0	-.1	.0	.1	.2	.0	.5	.2	.3	-.1	-.3	.1	-.2	.3	.6	.4	.7	.0	.8	.7	.6	.3	.7	-.2	.5	.5	.3	.6	.5	.5	.6	.6	-.4	.8	-.2	.8	.4	.4	-.4	.1	.5	-.5	-.1	-.1	.8	.4	.7	.9
20	.1	.2	.2	.1	.1	.2	.1	.2	.1	.2	.1	.1	-.3	.4	.1	.3	.4	.6	.3	.8	.4	.1	.5	.1	.4	.1	.6	.6	.3	.1	.3	.4	-.3	.6	-.4	.5	.3	.3	.2	.2	.2	-.1	.1	.2	.1	.0	.5	.5
21	.4	-.1	.0	.0	.0	.0	.0	.0	.0	.0	.3	-.1	-.5	.5	.3	.3	.6	.2	.1	.2	.8	-.1	.6	.2	.3	-.3	.1	.3	.5	.5	.0	.5	-.6	.6	-.4	.6	.5	.3	.4	.4	-.1	.3	.6	.6	-.2	-.1	.0	.1
22	.0	.0	-.1	.8	.3	-.2	.4	.3	.8	.0	-.3	.3	.2	-.1	.3	.2	.2	-.1	.6	.2	.0	.8	.3	-.3	.2	.3	.1	.2	-.2	-.2	.6	.5	-.5	.5	-.4	.5	.5	.2	-.4	.1	.6	-.4	.1	-.2	.5	.6	.7	.6
23	.5	-.2	-.3	.0	-.1	-.1	-.1	-.1	-.1	-.1	.4	-.1	-.3	.4	.4	.4	.6	.3	.1	.1	.7	.0	.8	.5	.6	-.2	.3	.4	.6	.6	-.2	.8	-.6	.7	-.5	.7	.7	.4	.6	.6	-.1	.4	.6	.6	-.1	-.1	-.1	.0
24	.8	-.6	-.1	-.1	-.1	-.1	.0	.0	.0	-.1	.4	-.4	-.3	.6	.4	.3	.4	.6	-.3	.1	.4	.0	.6	.8	.4	-.4	.3	.3	.5	.5	-.2	.4	-.3	.5	-.3	.3	.2	.2	.2	.7	-.3	.4	.2	.3	-.2	-.1	-.5	-.2
25	.8	-.4	-.3	-.3	-.1	-.1	-.1	.0	.0	-.1	.4	-.2	-.1	.3	.3	.4	.7	.4	.0	.4	.5	-.1	.8	.2	.8	-.1	.5	.7	.8	.8	.1	.6	-.6	.6	-.3	.6	.4	.3	.5	.8	-.3	.3	.6	.7	-.1	-.1	-.1	.1
26	-.2	.5	.6	.4	.3	.3	.0	.1	.6	.4	-.3	.6	.5	-.6	-.2	.0	-.6	-.1	-.1	-.1	-.1	.4	-.1	-.3	-.4	.8	-.2	-.3	-.6	-.6	-.3	-.2	.3	-.4	.7	.0	-.4	-.2	-.3	-.5	.4	-.6	-.3	-.3	.1	.3	.7	.3
27	.6	-.2	-.2	-.2	-.1	-.2	.0	.0	-.1	-.1	.5	-.1	-.2	.5	.3	.4	.5	.9	-.3	.4	.5	-.2	.7	.3	.6	-.2	.8	.8	.6	.5	-.3	.5	-.4	.4	-.2	.7	.4	.4	.7	.7	-.6	.6	.6	.4	-.4	-.1	-.4	-.4
28	.8	-.2	-.1	-.2	-.1	-.1	-.1	-.1	-.2	-.1	.6	-.1	-.2	.6	.4	.4	.6	.6	-.1	.4	.3	-.1	.7	.3	.7	-.2	.6	.8	.6	.6	-.1	.6	-.5	.6	-.4	.6	.5	.4	.6	.5	-.6	.6	.6	.4	-.3	-.2	-.1	.0
29	.8	-.3	-.2	-.2	-.2	-.2	-.3	-.3	-.2	-.2	.4	-.2	-.2	.6	.5	.3	.6	.5	-.2	.0	.5	-.1	.7	.5	.3	-.3	.4	.5	.8	.8	-.5	.6	-.4	.6	-.5	.6	.4	.4	.4	.5	-.6	.4	.6	.6	-.4	-.1	-.5	-.3
30	.6	-.3	-.4	-.2	-.1	-.1	-.1	-.2	-.2	-.2	.6	-.2	-.3	.6	.7	.4	.6	.4	-.1	.2	.4	-.1	.6	.3	.1	-.3	.3	.5	.7	.8	-.1	.6	-.6	.6	-.4	.6	.4	.3	.4	.8	-.2	.3	.3	.4	-.1	-.2	-.4	-.2
31	.0	.3	.2	.3	.4	.1	.1	.1	.1	-.2	-.4	.2	-.2	.4	.6	.2	.3	-.4	.8	.8	-.1	.3	.2	-.2	.2	.2	-.2	.2	.1	.1	.8	.2	.1	.2	-.1	.1	-.2	-.3	-.7	-.2	.8	-.8	-.6	-.5	.7	.3	.5	.6
32	.6	-.3	-.2	-.2	-.1	-.1	.0	.0	.0	-.1	.3	-.3	-.2	.3	.4	.4	.7	.4	-.1	.1	.5	-.1	.6	.1	.6	-.3	.3	.6	.6	.6	-.1	.8	-.5	.7	-.4	.6	.7	.4	.6	.5	-.3	.6	.8	.7	-.3	.1	.0	.0
33	-.2	.6	.3	.4	.2	.5	.1	.1	.4	.4	-.2	.4	.3	-.4	-.3	-.3	-.7	-.1	-.3	-.2	-.4	-.1	-.4	-.3	-.3	.4	-.3	-.5	-.6	-.5	-.1	-.6	.8	-.8	.6	-.6	-.7	-.6	-.7	-.6	.3	-.6	-.7	-.6	-.1	.2	.6	.1
34	.4	-.2	-.3	-.2	-.2	-.3	-.1	.0	.0	-.1	.4	-.3	-.2	.4	.5	.6	.7	.4	.0	.3	.5	-.1	.4	.3	.4	-.4	.2	.4	.6	.6	-.3	.7	-.7	.8	-.4	.6	.4	.4	.5	.5	-.2	.2	.5	.4	.0	-.1	.1	.3
35	-.1	.4	.6	.4	.3	.5	.3	.2	.4	.3	-.3	.6	.3	-.3	-.2	-.2	-.3	-.2	-.3	-.1	-.4	.2	.1	-.2	-.1	.6	.0	-.2	-.7	-.7	-.3	-.6	.6	-.2	.8	-.4	-.4	-.4	-.5	-.7	.5	-.6	-.5	-.4	-.3	.2	.8	-.1
36	.6	.0	-.1	.0	.1	-.1	.1	.1	-.1	.1	.4	-.3	-.3	.4	.5	.3	.6	.2	.0	.3	.4	-.2	.6	.3	.3	-.4	.4	.3	.5	.5	-.3	.6	-.6	.8	-.2	.8	.4	.4	.6	.4	-.4	.4	.7	.5	-.1	-.2	-.2	.1
37	.3	-.1	-.2	-.1	-.1	-.1	-.1	-.1	-.1	-.1	.1	-.2	-.1	.1	.2	.4	.5	.2	.0	.2	.4	-.1	.6	.2	.3	.0	.3	.3	.3	.4	.0	.6	-.6	.8	-.3	.6	.8	.7	.5	.5	-.4	.5	.4	.6	-.3	.0	-.2	-.1
38	.4	-.1	-.1	-.2	-.1	.0	.0	.0	.0	-.1	.2	-.2	.0	.1	.3	.2	.4	.2	.0	.1	.2	.0	.4	.1	.3	.0	.0	.3	.4	.3	.0	.4	-.4	.5	-.2	.4	.7	.8	.3	.4	-.3	.3	.3	.5	-.3	-.1	-.1	-.3
39	.5	-.2	-.1	-.1	.0	.0	-.1	-.1	-.1	.0	.5	-.2	-.1	.4	.1	.3	.7	.7	-.3	.1	.4	-.1	.6	.3	.4	-.1	.4	.4	.4	.4	.0	.4	-.5	.6	-.3	.5	.5	.4	.8	.6	-.5	.8	.6	.6	-.5	-.4	-.5	-.4
40	.8	-.3	-.1	.0	.0	.0	.0	.0	.0	.0	.4	-.3	-.2	.4	.3	.3	.4	.3	-.1	.2	.3	-.1	.8	.3	.1	-.3	.3	.6	.6	.6	-.3	.5	-.6	.5	-.4	.5	.3	.4	.4	.7	-.4	.5	.3	.4	-.2	-.3	-.4	-.1
41	-.1	.2	.3	.3	.3	.0	.2	.1	.1	.0	-.4	.2	.5	-.3	.2	.0	.0	-.5	.4	.3	.0	.1	.2	-.2	.0	.1	-.4	-.3	-.1	-.2	.5	-.1	.3	-.2	.3	.0	-.4	-.3	-.7	-.4	.8	-.8	-.7	-.7	.6	.2	.6	.8
42	.5	-.2	-.3	-.2	-.2	-.1	-.2	-.2	-.2	-.2	.6	-.2	-.2	.6	.2	.3	.5	.7	-.4	.1	.5	-.2	.5	.4	.4	-.3	.6	.5	.5	.5	-.2	.6	-.7	.5	-.4	.6	.5	.4	.9	.7	-.5	.8	.7	.6	-.4	-.2	-.2	-.2
43	.4	.0	-.2	-.2	-.1	-.1	-.1	.0	.0	.0	.4	-.3	-.1	.3	.4	.4	.7	.5	-.3	.0	.5	-.1	.7	.1	.4	-.1	.3	.3	.3	.4	-.2	.7	-.5	.7	-.4	.6	.5	.3	.6	.6	-.2	.4	.8	.6	-.1	-.1	.0	.0
44	.9	-.4	-.2	-.2	-.1	-.1	.1	.1	-.1	.0	.4	-.3	-.1	.3	.3	.3	.5	.3	.1	.4	.3	.0	.6	.4	.4	-.2	.5	.6	.8	.7	.1	.5	-.5	.5	-.2	.6	.3	.3	.3	.9	.0	.5	.3	.7	.0	-.1	-.1	.1
45	.0	.2	.4	.3	.3	.1	.1	.2	.4	-.1	-.5	.3	-.1	.0	.3	.3	.2	-.3	.9	.6	-.1	.2	.1	-.2	-.1	.2	-.3	.0	-.2	-.1	.8	.3	-.2	.3	.1	.1	-.1	-.1	-.9	-.4	.8	-.7	-.5	-.5	.6	.3	.6	.7
46	-.3	.7	.4	.6	.6	.5	.2	.2	.6	.4	-.4	.7	.6	-.5	.0	.0	-.3	-.4	.1	-.2	-.3	.7	-.3	-.2	.2	.7	-.1	.0	-.8	-.7	.0	-.6	.4	-.3	.7	-.4	-.5	-.3	-.7	-.7	.4	-.6	-.6	-.5	.3	.8	.8	.2
47	-.3	.6	.6	.5	.4	.3	.1	.1	.2	.1	-.2	.5	.3	-.2	-.1	.2	-.1	-.2	-.1	-.1	-.4	.0	-.5	-.3	-.1	.4	.0	-.3	-.3	-.3	.1	-.6	.6	-.7	.4	-.3	-.4	-.3	-.3	-.6	.5	-.4	-.5	-.4	.3	.4	.7	-.1
48	-.2	.1	.3	.3	.3	.0	.3	.3	.3	.1	-.2	.3	-.1	.3	.4	.3	.5	-.3	.5	.4	.3	.2	.5	-.1	.4	.0	.0	.4	.2	.4	.3	.6	-.7	.6	-.4	.3	.2	.2	-.2	.0	.1	-.3	-.3	.0	.3	.2	.7	.8

Table E11– Standard deviation matrix using *square ratio* numeric equivalent.

Standard Desviation Matrix

Equivalent Numeric: Fixed (NC= .00 AM= 1.00 A = .50 AP= .25 DM= -1.00 D = -.50 DP= -.25) with Square Ratio series.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1	.25	.46	.22	.53	.00	.35	.33	.33	.00	.33	.32	.00	.22	.25	.25	.43	.31	.74	.18	.24	.18	.00	.36	.46	.22	.00	.41	.25	.35	.38	.22	.35	.33	.31	.22	.33	.30	.24	.40	.22	.43	.37	.30	.40	.26	.36	.47	.43
2	.33	.26	.30	.38	.46	.31	.34	.34	.35	.33	.46	.28	.26	.52	.50	.25	.49	.50	.46	.35	.47	.25	.50	.46	.55	.36	.48	.56	.46	.39	.22	.46	.53	.30	.36	.50	.43	.50	.50	.46	.55	.53	.50	.50	.20	.33	.31	.51
3	.44	.40	.35	.40	.43	.30	.35	.33	.40	.39	.43	.43	.43	.36	.65	.55	.66	.61	.51	.43	.39	.47	.43	.49	.35	.28	.50	.57	.39	.43	.55	.43	.43	.42	.17	.46	.55	.50	.55	.46	.53	.50	.36	.43	.43	.25	.36	.60
4	.33	.36	.47	.36	.38	.51	.33	.24	.42	.25	.47	.38	.61	.58	.43	.30	.36	.30	.37	.34	.58	.30	.60	.22	.43	.40	.46	.49	.50	.49	.40	.51	.43	.53	.58	.57	.42	.48	.33	.43	.43	.49	.57	.35	.45	.35	.43	.43
5	.44	.26	.28	.61	.70	.47	.35	.08	.35	.22	.44	.36	.46	.44	.53	.22	.22	.40	.30	.18	.47	.45	.44	.25	.30	.44	.40	.25	.22	.43	.43	.43	.48	.57	.36	.36	.35	.22	.36	.36	.35	.36	.35	.43	.40	.39	.35	.35
6	.43	.41	.36	.42	.43	.36	.27	.11	.36	.41	.56	.52	.37	.46	.40	.22	.57	.46	.25	.25	.51	.20	.53	.25	.43	.44	.57	.62	.46	.49	.48	.57	.40	.61	.43	.42	.42	.35	.55	.49	.57	.53	.50	.44	.11	.50	.40	.46
7	.44	.44	.40	.37	.42	.49	.39	.35	.35	.18	.49	.30	.40	.42	.56	.22	.61	.43	.43	.39	.43	.43	.55	.35	.35	.37	.49	.66	.39	.43	.55	.49	.40	.42	.51	.61	.42	.58	.42	.61	.65	.39	.42	.44	.33	.33	.43	.39
8	.22	.42	.35	.38	.44	.47	.38	.35	.39	.47	.43	.38	.43	.51	.39	.25	.40	.58	.43	.43	.48	.57	.36	.36	.41	.46	.71	.75	.35	.44	.40	.47	.46	.36	.45	.49	.48	.35	.35	.42	.43	.43	.66	.43	.25	.22	.44	.30
9	.44	.30	.24	.35	.37	.21	.22	.22	.44	.21	.42	.39	.61	.66	.43	.30	.50	.50	.28	.24	.40	.37	.56	.24	.42	.49	.58	.57	.39	.42	.28	.43	.42	.43	.36	.60	.35	.35	.39	.44	.31	.35	.43	.49	.26	.35	.35	.55
10	.35	.33	.31	.31	.40	.31	.26	.22	.31	.36	.43	.40	.34	.47	.43	.36	.60	.45	.53	.48	.36	.31	.57	.35	.46	.49	.56	.68	.43	.35	.43	.42	.59	.40	.40	.62	.42	.42	.40	.46	.56	.40	.33	.43	.47	.33	.45	.46
11	.40	.49	.44	.44	.44	.35	.35	.35	.44	.44	.35	.35	.43	.31	.36	.35	.44	.37	.26	.26	.31	.35	.39	.35	.35	.35	.46	.39	.30	.42	.44	.44	.43	.40	.35	.44	.44	.42	.38	.44	.43	.43	.39	.43	.44	.36	.43	.46
12	.33	.31	.31	.36	.33	.23	.33	.22	.35	.37	.36	.35	.36	.40	.34	.43	.66	.46	.54	.47	.59	.37	.52	.55	.54	.48	.61	.61	.42	.43	.42	.56	.50	.56	.50	.71	.53	.49	.39	.43	.22	.43	.33	.36	.35	.23	.40	.57
13	.44	.42	.41	.24	.35	.23	.21	.24	.34	.38	.36	.40	.39	.53	.62	.25	.43	.44	.55	.53	.33	.18	.35	.38	.22	.34	.42	.43	.49	.55	.64	.44	.43	.51	.37	.54	.43	.30	.42	.42	.31	.42	.36	.36	.48	.13	.41	.40
14	.40	.42	.43	.25	.28	.17	.22	.30	.22	.49	.33	.35	.50	.35	.55	.36	.39	.31	.46	.33	.36	.44	.40	.43	.36	.43	.65	.65	.45	.43	.57	.49	.44	.49	.43	.46	.25	.25	.42	.61	.65	.24	.33	.43	.40	.17	.42	.43
15	.42	.35	.41	.35	.38	.30	.17	.17	.00	.18	.26	.36	.22	.36	.35	.50	.39	.70	.24	.49	.36	.17	.39	.44	.56	.36	.56	.61	.46	.45	.42	.40	.39	.43	.46	.45	.39	.43	.28	.40	.48	.51	.40	.25	.33	.20	.41	.33
16	.45	.43	.54	.40	.40	.27	.22	.22	.26	.00	.25	.56	.44	.63	.43	.43	.39	.22	.44	.22	.42	.17	.56	.52	.43	.46	.43	.49	.54	.54	.33	.61	.53	.39	.25	.46	.39	.37	.31	.35	.42	.32	.43	.25	.23	.42	.35	.43
17	.46	.44	.48	.38	.35	.11	.08	.00	.33	.17	.35	.55	.22	.36	.36	.43	.35	.42	.31	.33	.41	.17	.36	.35	.33	.46	.61	.31	.39	.39	.41	.30	.60	.33	.53	.36	.34	.46	.43	.51	.45	.33	.36	.43	.50	.39	.62	.44
18	.35	.36	.30	.25	.20	.17	.17	.17	.17	.20	.32	.43	.36	.28	.38	.26	.33	.35	.25	.43	.43	.00	.43	.36	.44	.44	.31	.42	.33	.35	.22	.35	.50	.35	.43	.33	.39	.33	.30	.42	.39	.35	.32	.24	.43	.44	.35	.26
19	.26	.39	.44	.45	.35	.40	.34	.56	.35	.35	.44	.53	.44	.43	.49	.49	.43	.59	.35	.39	.50	.43	.43	.38	.43	.40	.50	.43	.40	.40	.41	.38	.64	.40	.62	.31	.65	.42	.49	.55	.33	.43	.78	.57	.36	.33	.36	.28
20	.38	.34	.24	.18	.22	.24	.33	.22	.31	.36	.21	.47	.43	.45	.42	.33	.31	.42	.50	.35	.37	.21	.36	.28	.45	.22	.46	.42	.33	.45	.35	.31	.61	.37	.46	.41	.41	.45	.43	.38	.51	.45	.47	.22	.37	.20	.35	.51
21	.40	.38	.22	.00	.00	.00	.00	.00	.00	.00	.24	.39	.51	.44	.35	.35	.45	.55	.31	.24	.36	.17	.31	.42	.25	.47	.49	.36	.44	.44	.44	.40	.42	.42	.49	.39	.36	.35	.40	.45	.50	.43	.30	.39	.51	.17	.48	.31
22	.40	.57	.56	.36	.56	.66	.42	.35	.36	.45	.44	.42	.43	.47	.43	.35	.43	.38	.43	.41	.51	.35	.61	.43	.43	.67	.55	.57	.57	.57	.37	.22	.35	.32	.42	.38	.40	.35	.42	.70	.43	.39	.52	.43	.41	.46	.50	.39
23	.48	.36	.51	.20	.17	.17	.17	.17	.17	.33	.42	.38	.44	.42	.40	.40	.38	.43	.45	.49	.39	.54	.44	.44	.39	.39	.61	.68	.45	.45	.51	.40	.49	.44	.50	.35	.43	.46	.39	.45	.43	.40	.42	.42	.38	.17	.38	.29
24	.30	.46	.33	.33	.33	.33	.00	.00	.00	.33	.47	.47	.43	.47	.42	.56	.42	.43	.47	.53	.40	.00	.50	.35	.47	.49	.33	.33	.43	.43	.35	.42	.43	.48	.50	.43	.54	.54	.56	.36	.43	.40	.62	.61	.35	.17	.50	.36
25	.25	.49	.43	.44	.33	.35	.33	.00	.00	.39	.47	.44	.22	.36	.35	.42	.35	.42	.50	.31	.36	.22	.31	.51	.35	.53	.36	.26	.25	.36	.39	.38	.38	.33	.43	.35	.37	.34	.36	.25	.46	.35	.28	.35	.53	.22	.33	.30
26	.50	.51	.67	.65	.61	.43	.40	.35	.40	.40	.44	.42	.43	.46	.63	.54	.46	.77	.67	.43	.49	.38	.68	.56	.49	.35	.61	.67	.42	.42	.51	.43	.50	.53	.43	.59	.45	.36	.43	.50	.47	.35	.43	.50	.42	.43	.67	.44
27	.53	.51	.50	.50	.39	.44	.50	.50	.60	.33	.48	.64	.44	.50	.67	.49	.44	.22	.54	.31	.40	.35	.43	.35	.39	.79	.35	.30	.65	.69	.47	.40	.50	.68	.61	.43	.47	.47	.35	.43	.38	.38	.42	.68	.49	.53	.70	.49
28	.40	.50	.39	.50	.39	.39	.39	.39	.50	.39	.53	.60	.44	.53	.49	.46	.39	.42	.45	.37	.43	.37	.43	.35	.43	.61	.45	.35	.67	.67	.45	.35	.43	.46	.49	.42	.48	.47	.42	.67	.58	.43	.42	.65	.54	.36	.63	.57
29	.30	.43	.44	.44	.44	.44	.50	.50	.44	.44	.68	.44	.44	.49	.35	.43	.39	.35	.54	.44	.43	.33	.43	.44	.66	.50	.70	.67	.35	.40	.54	.43	.55	.39	.50	.45	.55	.42	.49	.40	.55	.43	.39	.42	.49	.22	.50	.35
30	.47	.50	.53	.44	.39	.33	.33	.44	.44	.44	.53	.44	.43	.49	.43	.49	.42	.42	.43	.22	.33	.33	.49	.43	.68	.44	.66	.67	.39	.36	.52	.35	.42	.28	.49	.43	.40	.35	.65	.31	.52	.38	.38	.37	.41	.35	.56	.49
31	.20	.43	.43	.43	.46	.18	.18	.18	.22	.46	.49	.33	.61	.46	.39	.61	.61	.49	.35	.36	.47	.41	.50	.35	.67	.54	.61	.75	.65	.66	.35	.57	.65	.36	.55	.59	.53	.46	.36	.51	.39	.44	.49	.48	.36	.35	.44	.42
32	.37	.41	.39	.35	.17	.17	.08	.08	.00	.17	.44	.35	.43	.35	.33	.46	.36	.42	.45	.18	.36	.17	.42	.39	.46	.43	.66	.39	.33	.33	.18	.35	.71	.26	.49	.39	.43	.46	.42	.40	.46	.46	.26	.35	.44	.39	.62	.59
33	.35	.43	.57	.31	.34	.35	.22	.22	.39	.40	.36	.28	.35	.53	.43	.43	.43	.52	.43	.43	.46	.33	.49	.44	.43	.55	.56	.50	.42	.43	.35	.49	.35	.30	.42	.50	.50	.53	.50	.45	.61	.53	.50	.53	.35	.36	.46	.17
34	.46	.35	.36	.35	.35	.50	.33	.00	.00	.33	.42	.46	.36	.46	.44	.46	.35	.42	.34	.34	.44	.33	.40	.35	.40	.46	.54	.42	.46	.46	.47	.50	.44	.36	.53	.46	.46	.46	.50	.48	.56	.62	.44	.47	.48	.53	.64	.41
35	.53	.37	.43	.40	.35	.41	.44	.35	.46	.61	.44	.36	.43	.50	.50	.46	.57	.51	.43	.38	.49	.43	.42	.35	.17	.49	.50	.51	.36	.36	.47	.43	.49	.71	.35	.63	.42	.42	.40	.43	.48	.30	.35	.40	.46	.50	.44	.53
36	.45	.51	.60	.40	.39	.53	.39	.39	.55	.39	.49	.67	.44	.49	.44	.43	.40	.62	.56	.35	.39	.35	.37	.25	.43	.49	.49	.66	.41	.48	.67	.40	.38	.26	.67	.35	.42	.42	.39	.40	.49	.42	.35	.36	.40	.44	.68	.22
37	.20	.17	.35	.17	.17	.17	.17	.17	.17	.17	.55	.33	.17	.22	.25	.33	.36	.36	.25	.25	.45	.17	.35	.28	.33	.00	.36	.35	.33	.27	.25	.33	.43	.26	.50	.31	.35	.39	.40	.41	.49	.40	.38	.43	.44	.25	.54	.43
38	.31	.17	.33	.35	.33	.08	.08	.08	.08	.33	.36	.44	.08	.25	.43	.36	.39	.36	.22	.17	.34	.00	.40	.49	.35	.00	.44	.35	.40	.35	.00	.40	.49	.50	.35	.47	.39	.35	.34	.37	.44	.35	.35	.44	.44	.17	.56	.44
39	.36	.24	.18	.18	.08	.08	.18	.18	.18	.08	.43	.35	.22	.47	.47	.25	.35	.26	.44	.22	.40	.33	.45	.36	.31	.33	.31	.22	.39	.42	.00	.39	.50	.35	.44	.41	.35	.42	.35	.39	.50	.31	.38	.42	.50	.49	.54	.49
40	.25	.43	.17	.08	.08	.08	.08	.08	.08	.08	.46	.50	.35	.42	.35	.36	.33	.36	.38	.24	.33	.33	.36	.25	.74	.50	.67	.46	.42	.42	.44	.43	.49	.43	.49	.43	.62	.42	.49	.39	.52	.50	.66	.48	.35	.44	.49	.42
41	.17	.36	.41	.42	.43	.51	.18	.13	.18	.40	.49	.56	.43	.43	.62	.44	.59	.50	.39	.33	.48	.33	.41	.36	.50	.51	.58	.58	.45	.53	.40	.47	.35	.61	.42	.66	.50	.46	.44	.49	.35	.35	.44	.50	.38	.34	.46	.36
42	.40	.35	.50	.44	.35	.33	.35	.44	.44	.35	.42	.44	.44	.50	.62	.43	.44	.36	.60	.46	.44	.44	.43	.40	.42	.57	.35	.40	.43	.43	.44	.45	.50	.40	.49	.45	.44	.47	.17	.39	.50	.35	.36	.46	.49	.61	.51	.43
43	.31	.20	.50	.35	.17	.17	.17	.08	.13	.08	.46	.47	.17	.43	.42	.46	.36	.48	.59	.48	.44	.33	.44	.49	.38	.33	.33	.18	.33	.31	.44	.26	.43	.39	.52	.33	.44	.35	.42	.39	.46	.46	.35	.44	.38	.38	.61	.54
44	.17	.49	.44	.44	.33	.33	.33	.33	.17	.08	.40	.50	.17	.43	.41	.35	.45	.38	.53	.31	.39	.00	.53	.47	.40	.44	.44	.28	.26	.36	.45	.40	.57	.44	.44	.42	.61	.35	.42	.17	.20	.32	.35	.44	.38	.53	.66	.65
45	.26	.43	.27	.33	.35	.22	.18	.24	.33	.35	.50	.38	.35	.26	.61	.35	.56	.55	.33	.35	.50	.34	.42	.35	.42	.48	.67	.59	.45	.49	.25	.33	.61	.56	.22	.62	.70	.55	.22	.53	.36	.36	.54	.54	.70	.34	.33	.43
46	.53	.39	.63	.42	.43	.40	.35	.35	.46	.40	.53	.44	.46	.43	.56	.54	.62	.49	.55	.48	.44	.44	.56	.51	.66	.56	.68	.75	.44	.50	.71	.46	.46	.45	.50	.65	.50	.44	.44	.50	.53	.42	.42	.40	.43	.35	.25	.44
47	.50	.42	.45	.50	.47	.43	.33	.18	.22	.22	.35	.48	.44	.35	.53	.50	.55	.50	.42	.55	.42	.00	.43	.56	.53	.47	.56	.44	.41	.43	.22	.43	.52	.36	.40	.66	.46	.43	.43	.49	.48	.42	.43	.49	.43	.47	.44	.53
48	.68	.53	.34	.43	.44	.40	.43	.41	.43	.18	.44	.41	.63	.66	.70	.62	.67	.61	.25	.40	.43	.61	.25	.22	.39	.57	.67	.65	.55	.31	.31	.35	.50	.42	.50	.66	.55	.34	.79	.66	.85	.75	.79	.67	.61	.61	.43	.35

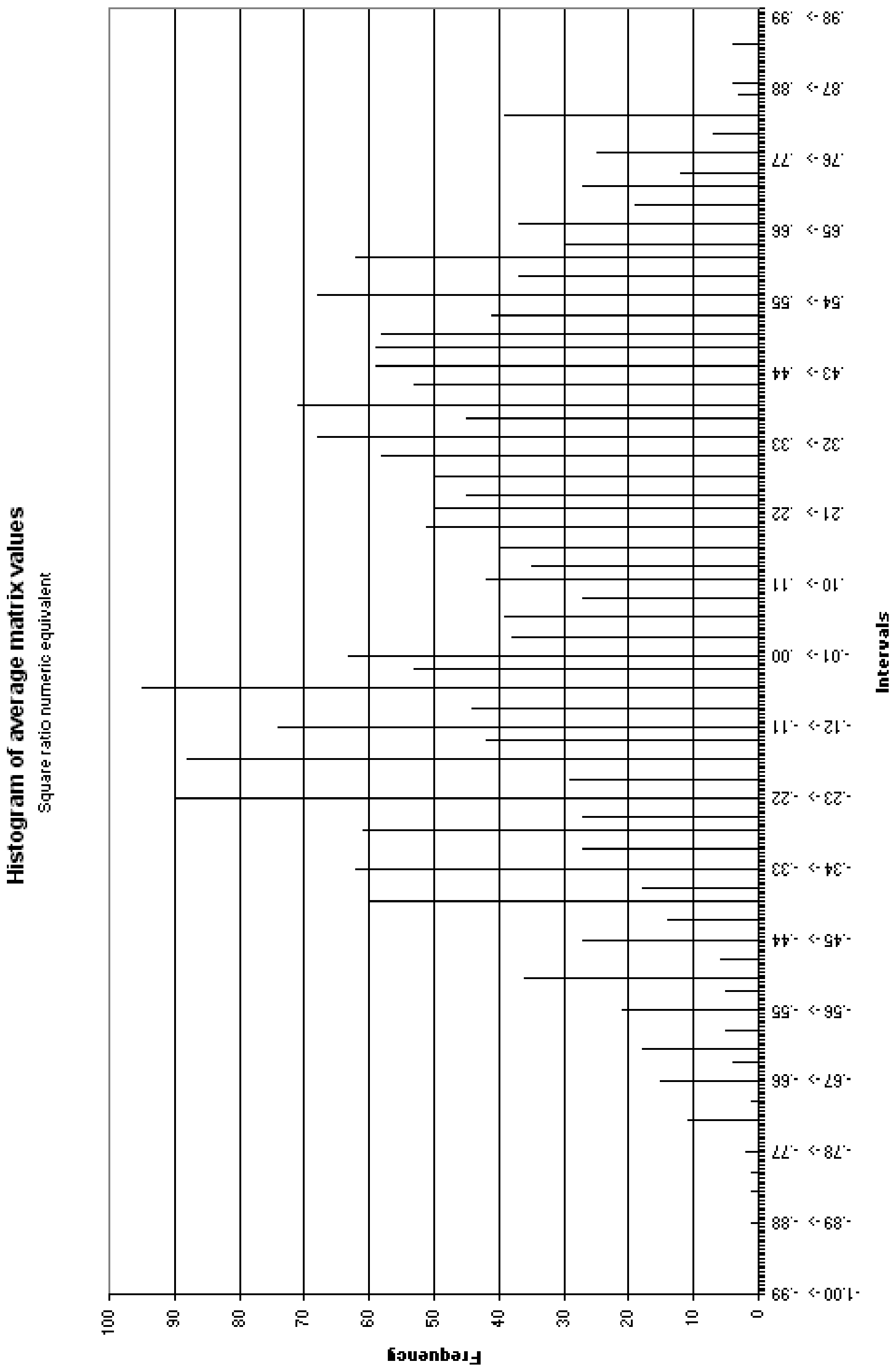

Figure E4 — Histogram of General Average Matrix values using *square ratio* numeric equivalent.

Table E12 – Energy of activation of each concept using *square ratio* numeric equivalent (increasing order).

Activation Energy

Ordered Answers Concerning Activation Energy
Numeric Equivalent: *Square Ratio* series.

Concept	Activ.+	Concept	Activ.-	Concept	BeAct.+	Concept	BeAct.-
13 ==>	6.6	33 ==>	-13.3	8 ==>	5.8	33 ==>	-16.6
33 ==>	7.3	46 ==>	-11.7	7 ==>	6.1	42 ==>	-11.8
5 ==>	7.9	10 ==>	-11.0	10 ==>	6.7	35 ==>	-11.2
47 ==>	8.4	35 ==>	-10.9	6 ==>	7.2	39 ==>	-10.6
10 ==>	8.7	26 ==>	-10.8	22 ==>	7.6	40 ==>	-10.1
6 ==>	9.1	2 ==>	-10.1	33 ==>	7.6	29 ==>	-9.9
38 ==>	9.2	6 ==>	-9.7	31 ==>	8.3	30 ==>	-9.8
35 ==>	9.5	3 ==>	-9.7	46 ==>	8.5	41 ==>	-9.8
41 ==>	9.7	9 ==>	-9.6	35 ==>	8.6	43 ==>	-9.6
9 ==>	10.3	12 ==>	-9.5	13 ==>	8.9	44 ==>	-8.6
2 ==>	10.4	47 ==>	-9.2	45 ==>	9.0	37 ==>	-7.4
12 ==>	11.0	41 ==>	-9.0	24 ==>	9.1	11 ==>	-7.2
26 ==>	11.1	13 ==>	-8.9	5 ==>	9.3	45 ==>	-7.1
18 ==>	11.2	45 ==>	-7.7	3 ==>	10.1	34 ==>	-7.1
37 ==>	11.4	31 ==>	-7.6	4 ==>	10.3	14 ==>	-6.9
24 ==>	11.5	29 ==>	-7.5	19 ==>	10.4	47 ==>	-6.9
16 ==>	12.0	8 ==>	-7.2	11 ==>	10.5	19 ==>	-6.8
40 ==>	12.0	27 ==>	-6.8	9 ==>	10.6	26 ==>	-6.8
21 ==>	12.1	48 ==>	-6.7	2 ==>	10.9	2 ==>	-6.7
45 ==>	12.1	42 ==>	-6.4	26 ==>	11.3	31 ==>	-6.7
3 ==>	12.2	30 ==>	-6.2	42 ==>	11.4	18 ==>	-6.5
11 ==>	12.2	7 ==>	-6.1	16 ==>	11.8	27 ==>	-6.5
39 ==>	12.6	22 ==>	-5.9	48 ==>	11.8	13 ==>	-6.4
14 ==>	12.6	5 ==>	-5.6	38 ==>	12.1	24 ==>	-6.4
1 ==>	12.8	28 ==>	-5.5	41 ==>	12.4	48 ==>	-6.3
46 ==>	12.9	4 ==>	-5.4	20 ==>	12.5	36 ==>	-6.3
31 ==>	13.1	24 ==>	-5.3	14 ==>	12.5	28 ==>	-6.2
43 ==>	13.1	11 ==>	-5.3	12 ==>	12.8	32 ==>	-6.2
34 ==>	13.3	36 ==>	-5.2	44 ==>	13.2	12 ==>	-6.1
30 ==>	13.4	14 ==>	-5.1	39 ==>	13.8	3 ==>	-6.0
15 ==>	13.4	34 ==>	-5.0	18 ==>	13.8	38 ==>	-5.7
20 ==>	13.5	40 ==>	-5.0	21 ==>	14.4	17 ==>	-5.6
4 ==>	14.1	39 ==>	-4.7	15 ==>	14.4	23 ==>	-5.5
36 ==>	14.1	19 ==>	-4.5	25 ==>	14.6	21 ==>	-5.1
29 ==>	14.1	18 ==>	-4.4	27 ==>	14.6	4 ==>	-4.3
42 ==>	14.3	23 ==>	-4.3	1 ==>	14.7	15 ==>	-4.2
32 ==>	14.4	32 ==>	-4.3	43 ==>	14.9	1 ==>	-4.1
44 ==>	14.4	25 ==>	-4.0	37 ==>	15.4	46 ==>	-3.9
7 ==>	14.6	43 ==>	-3.9	30 ==>	15.8	6 ==>	-3.7
23 ==>	14.7	44 ==>	-3.9	40 ==>	15.9	10 ==>	-3.6
8 ==>	14.8	15 ==>	-3.8	29 ==>	16.1	25 ==>	-3.4
22 ==>	14.9	21 ==>	-3.4	28 ==>	17.4	20 ==>	-3.3
25 ==>	15.1	37 ==>	-3.3	32 ==>	17.8	22 ==>	-3.0
48 ==>	15.2	1 ==>	-3.3	17 ==>	18.7	5 ==>	-3.0
17 ==>	16.2	17 ==>	-3.2	47 ==>	18.7	16 ==>	-2.8
28 ==>	16.3	38 ==>	-2.9	36 ==>	19.4	7 ==>	-2.3
27 ==>	16.4	16 ==>	-2.9	23 ==>	19.9	9 ==>	-2.2
19 ==>	17.9	20 ==>	-2.5	34 ==>	20.3	8 ==>	-2.0

Table E13 – General Average Matrix using *exponential ratio* numeric equivalent.

Average Matrix

Equivalent Numeric: Fixed (NC= .00 AM= 1.00 A = .84 AP= .51 DM= -1.00 D = -.84 DP= -.51) with Exponential Ratio series.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	.9	-.2	-.2	-.1	.0	-.2	.1	.1	.0	-.2	.7	.0	-.2	.8	.4	.1	.8	.4	.1	.3	.7	.0	.9	.6	.1
2	-.1	.9	.7	.5	.5	.6	.3	.3	.9	.5	-.2	.9	.9	-.4	-.3	-.1	-.4	-.1	.0	.4	-.3	.4	-.5	-.6	.2
3	-.2	.7	.9	.7	.6	.5	.4	.5	.6	.7	-.4	.7	.7	-.3	-.1	.0	-.2	.3	-.3	-.1	-.2	.2	-.6	-.4	.4
4	-.1	.7	.1	.9	.8	.0	.2	.3	.7	.2	-.3	.8	.2	-.1	.4	.1	.5	-.1	.7	.4	.1	.9	.2	-.2	.3
5	-.2	.4	.7	.4	.6	.3	-.1	.1	.4	.4	-.2	.4	.5	-.3	-.1	-.2	-.2	-.1	-.1	.1	-.3	.2	-.3	-.3	-.1
6	-.3	.6	.7	.3	.4	.9	.1	.1	.7	.6	-.1	.7	.7	-.6	-.3	-.2	-.1	.0	-.1	-.1	-.2	.0	.0	-.3	-.2
7	-.2	.6	.5	.7	.5	.5	.8	.8	.8	.6	-.4	.9	.6	-.5	.1	-.2	.4	-.1	.6	.7	.3	.7	.2	-.3	.4
8	-.2	.7	.8	.8	.4	.3	.7	.9	.8	.3	-.6	.8	.4	-.3	.1	-.1	.2	-.1	.6	.7	.4	.5	.5	-.3	.2
9	-.2	.9	.5	.7	.6	.4	.3	.3	.8	.4	-.5	.8	.5	-.4	.3	-.1	-.4	-.2	.0	.3	-.6	.6	-.5	-.3	.2
10	-.2	.8	.6	.6	.6	.6	.4	.2	.6	.9	-.4	.7	.9	-.5	-.2	-.3	-.4	-.1	-.2	-.6	-.4	.2	-.2	-.4	-.2
11	.7	-.4	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2	.9	-.2	-.4	.6	.4	.3	.6	.7	-.1	.1	.6	-.2	.6	.4	.4
12	-.1	.9	.6	.7	.5	.5	.5	.4	.8	.6	-.4	.9	.7	-.6	.4	-.1	-.2	-.2	.4	.2	.0	.6	-.3	-.2	.4
13	-.2	.5	.4	.3	.4	.4	.4	.3	.4	.6	-.4	.5	.8	-.4	-.3	-.3	-.4	-.3	-.4	-.5	-.2	.2	-.4	-.4	-.2
14	.7	-.5	-.4	-.3	-.2	-.1	-.2	-.1	-.2	-.4	.5	-.3	-.3	.9	.2	.3	.6	.6	.0	.7	.7	-.3	.7	.7	.4
15	.5	-.2	.0	-.2	-.1	-.1	-.1	-.1	.0	-.1	.4	-.3	-.2	.4	.9	.5	.8	-.1	.5	.3	.7	-.1	.8	.6	.3
16	.1	-.1	.0	.1	.1	.1	-.2	-.2	.1	.0	.1	.1	.0	.1	.4	.7	.7	.3	.3	.2	.5	-.1	.4	-.1	.4
17	.5	-.3	.0	-.1	-.2	.1	.1	.0	.1	-.1	.3	-.2	-.2	.4	.7	.6	.9	.5	.6	.5	.7	.1	.9	-.1	.5
18	.5	-.4	-.3	-.3	.0	-.1	-.1	-.1	-.1	.0	.7	-.1	-.4	.7	.0	.1	.5	.9	-.1	.3	.4	.0	.6	.7	.6
19	.1	.0	.1	.2	.3	.0	.7	.3	.4	-.1	-.3	.1	-.2	.3	.6	.4	.7	.0	.9	.8	.6	.4	.7	-.2	.6
20	.1	.3	.3	.3	.2	.3	.2	.3	.1	.3	.1	.1	-.4	.5	.2	.4	.6	.7	.4	.9	.6	.1	.7	.2	.5
21	.6	-.1	.0	.0	.0	.0	.0	.0	.0	.0	.5	.0	-.5	.6	.5	.5	.7	.4	.2	.3	.9	-.1	.8	.3	.4
22	.0	.1	.0	.9	.4	-.2	.5	.4	.9	.1	-.3	.4	.3	-.1	.4	.3	.3	-.1	.7	.2	.0	.9	.3	-.4	.3
23	.6	-.3	-.3	.0	-.1	-.1	-.1	-.1	-.1	-.2	.5	-.1	-.3	.5	.5	.6	.8	.4	.2	.3	.8	.0	.8	.6	.7
24	.9	-.6	-.2	-.1	-.1	-.1	.0	.0	.0	-.1	.4	-.5	-.4	.7	.5	.3	.5	.7	-.3	.1	.5	.0	.6	.9	.5
25	.9	-.4	-.3	-.3	-.1	-.1	-.1	.0	.0	.0	.5	-.2	-.2	.4	.4	.5	.8	.5	.1	.6	.7	-.2	.9	.2	.9
26	-.1	.6	.7	.5	.4	.4	.0	.1	.7	.5	-.3	.7	.6	-.6	-.2	.0	-.6	-.1	-.1	-.1	-.1	.6	.0	-.3	-.4
27	.7	-.2	-.2	-.2	.0	-.2	.0	.0	-.1	-.1	.6	-.1	-.2	.5	.3	.4	.6	1.0	-.3	.6	.7	-.2	.7	.4	.7
28	.8	-.1	.0	-.1	.0	.0	.0	.0	-.1	.0	.6	-.1	-.2	.6	.4	.5	.7	.7	.0	.6	.4	.0	.7	.4	.7
29	.9	-.4	-.2	-.2	-.2	-.2	-.3	-.3	-.2	-.2	.5	-.2	-.2	.6	.7	.4	.7	.7	-.1	.1	.6	-.1	.7	.6	.4
30	.7	-.3	-.4	-.2	.0	-.1	-.1	-.2	-.2	-.2	.6	-.2	-.3	.6	.7	.4	.7	.5	-.1	.3	.5	-.1	.6	.4	.2
31	.0	.4	.2	.4	.5	.2	.2	.1	.2	-.2	-.4	.3	-.2	.5	.7	.2	.4	-.4	.9	.9	-.1	.4	.4	-.2	.3
32	.7	-.4	-.2	-.2	-.1	-.1	.1	.1	.0	-.1	.3	-.4	-.2	.4	.5	.5	.8	.5	.0	.3	.7	-.1	.7	.0	.6
33	-.2	.7	.5	.6	.3	.7	.2	.2	.6	.5	-.3	.7	.4	-.4	-.4	-.4	-.7	-.1	-.4	-.2	-.5	-.1	-.4	-.3	-.4
34	.5	-.2	-.4	-.2	-.2	-.3	-.2	.0	.0	-.1	.5	-.3	-.3	.5	.6	.6	.8	.5	.1	.4	.6	-.1	.6	.5	.6
35	-.1	.6	.7	.5	.4	.6	.3	.3	.5	.4	-.3	.8	.4	-.3	-.1	-.2	-.2	-.2	-.4	-.1	-.4	.3	.1	-.2	-.1
36	.7	-.1	-.2	.0	.0	-.1	.0	.0	-.2	.0	.4	-.3	-.3	.4	.6	.4	.7	.3	.0	.4	.6	-.2	.7	.4	.4
37	.5	-.1	-.3	-.1	-.1	-.1	-.1	-.1	-.1	-.1	.2	-.3	-.1	.2	.3	.5	.7	.3	.0	.3	.5	-.1	.8	.3	.5
38	.6	-.1	-.1	-.2	-.2	-.1	-.1	-.1	-.1	-.2	.3	-.2	.1	.1	.4	.3	.6	.3	.0	.1	.3	.0	.6	.3	.4
39	.7	-.3	-.1	-.1	-.1	-.1	-.1	-.1	-.1	-.1	.6	-.3	-.2	.5	.2	.4	.8	.9	-.3	.2	.6	-.1	.7	.4	.6
40	.9	-.4	-.1	-.1	-.1	-.1	-.1	-.1	-.1	-.1	.5	-.3	-.2	.5	.5	.4	.6	.4	-.1	.3	.5	-.1	.9	.6	.2
41	-.1	.3	.4	.3	.4	.1	.3	.2	.2	.0	-.4	.3	.6	-.4	.3	.1	.1	-.5	.6	.5	.0	.2	.2	-.3	.1
42	.7	-.2	-.3	-.2	-.2	-.1	-.2	-.2	-.2	-.2	.7	-.2	-.2	.6	.1	.4	.6	.8	-.4	.2	.6	-.2	.6	.6	.5
43	.6	.0	-.1	-.2	-.1	-.1	-.1	-.1	.0	-.1	.5	-.3	-.1	.4	.5	.5	.8	.6	-.2	.0	.6	-.1	.8	.3	.5
44	1.0	-.4	-.2	-.2	-.1	-.1	.2	.2	-.1	-.1	.5	-.3	-.1	.4	.4	.4	.6	.4	.1	.6	.4	.0	.6	.5	.6
45	.1	.3	.7	.5	.4	.2	.2	.3	.5	-.1	-.5	.4	-.1	.1	.4	.4	.3	-.2	.9	.8	-.1	.3	.2	-.2	-.1
46	-.3	.8	.6	.7	.7	.7	.3	.3	.6	.5	-.4	.8	.6	-.6	.0	.0	-.4	-.4	.2	-.1	-.3	.8	-.3	-.2	.2
47	-.3	.7	.7	.5	.5	.4	.2	.1	.3	.2	-.2	.6	.3	-.2	-.1	.1	-.2	-.1	-.1	.0	-.5	.0	-.6	-.3	-.1
48	-.2	.2	.4	.4	.3	.0	.4	.4	.4	.1	-.2	.4	-.1	.3	.4	.4	.6	-.3	.8	.5	.5	.3	.8	-.2	.6

	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1	.0	.2	.4	.8	.8	-.2	.8	-.6	.8	-.2	.8	.7	.3	.7	1.0	-.4	.6	.8	.7	-.4	-.3	-.3	-.2
2	.7	.1	-.1	-.6	-.6	-.2	-.5	.6	-.8	.7	-.5	-.6	-.4	-.4	-.6	.2	-.5	-.4	-.5	.0	.5	.9	-.2
3	.9	.1	-.2	-.7	-.7	-.2	-.4	.6	-.7	1.0	-.5	-.4	-.4	-.4	-.6	.5	-.2	-.4	-.4	.3	.4	.9	.2
4	.6	.0	.1	-.1	-.3	.7	.3	-.4	.5	-.2	.1	.4	.0	-.2	-.4	.5	-.5	-.2	-.4	.7	.7	.7	.7
5	.6	.0	-.1	-.2	-.1	.2	-.2	.0	.1	.8	-.3	-.2	-.2	-.3	-.3	.5	-.4	-.2	-.4	.6	.6	.8	.4
6	.6	-.2	-.2	-.6	-.6	-.3	-.4	.5	-.3	.6	-.5	-.5	-.5	-.1	-.4	-.1	-.5	-.2	-.3	.1	.4	.8	-.4
7	.6	.1	.2	-.7	-.6	.4	.3	-.1	.4	-.1	.1	.4	.1	-.5	-.2	.5	-.6	-.5	-.3	.5	.5	.7	.7
8	.7	.1	.3	-.8	-.8	.5	-.1	-.4	.4	-.1	.5	.0	-.1	-.4	-.5	.7	-.6	-.3	-.4	.6	.4	.8	.9
9	.5	.1	-.1	-.7	-.7	.2	-.6	.7	-.7	.7	-.2	-.4	-.4	-.6	-.8	.6	-.7	-.6	-.4	.4	.5	.8	.2
10	.5	.1	.0	-.7	-.8	-.4	-.5	.1	-.6	.7	-.4	-.5	-.5	-.7	-.6	.3	-.6	-.6	-.4	-.3	.5	.7	-.4
11	-.2	.5	.6	.9	.7	-.2	.6	-.4	.6	-.2	.6	.6	.5	.8	.8	-.4	.6	.7	.6	-.3	-.3	-.4	-.5
12	.4	-.1	-.4	-.7	-.6	.2	-.2	.4	-.3	.3	-.3	-.5	-.5	-.6	-.7	.6	-.6	-.6	-.4	.1	.5	.7	.2
13	.4	-.5	-.3	-.5	-.4	.0	-.3	.3	-.3	.3	-.3	-.4	-.1	-.5	-.5	.6	-.5	-.3	-.4	.0	.2	.6	-.1
14	-.4	.5	.5	.7	.7	.1	.4	-.3	.6	-.4	.6	.6	.3	.5	.5	-.1	.3	.5	.6	.0	-.1	-.2	.2
15	-.4	.3	.4	.6	.7	.2	.7	-.6	.7	-.5	.7	.7	.6	.3	.7	.4	.0	.6	.4	.4	.0	.2	.5
16	.0	.4	.4	.1	.1	.2	.4	-.1	.7	-.3	.5	.7	.6	.6	.3	.3	.0	.5	.3	.4	.1	.9	.4
17	.2	.4	.8	.7	.7	.1	.9	-.6	.9	-.4	.8	.9	.6	.7	.5	-.1	.6	.8	.6	.3	.0	.2	.3
18	-.2	.9	.7	.6	.5	-.2	.4	-.4	.5	-.4	.5	.6	.6	.8	.5	-.7	.7	.7	.5	-.4	-.2	-.1	-.5
19	.7	.4	.7	.7	.7	.7	.8	-.6	.8	-.3	.9	.5	.5	-.5	.2	.7	-.6	.0	-.1	.9	.5	.8	.9
20	.2	.6	.7	.4	.2	.4	.6	-.4	.7	-.5	.6	.4	.4	.3	.3	.3	.0	.3	.3	.1	.0	.7	.6
21	-.3	.3	.4	.6	.6	.0	.7	-.7	.7	-.4	.7	.7	.5	.6	.5	-.1	.4	.8	.7	-.2	-.1	.0	.1
22	.3	.2	.4	-.1	-.1	.7	.8	-.7	.7	-.5	.7	.7	.3	-.5	.1	.7	-.6	.1	-.2	.6	.6	.7	.7
23	-.2	.4	.5	.7	.7	-.2	.8	-.6	.8	-.5	.8	.7	.5	.7	.7	-.1	.6	.7	.7	-.1	-.1	-.1	.1
24	-.4	.5	.5	.6	.6	-.2	.5	-.4	.6	-.3	.4	.3	.3	.3	.8	-.4	.6	.3	.4	-.2	-.1	-.5	-.3
25	-.1	.7	.9	.9	.9	.0	.8	-.8	.8	-.4	.8	.6	.4	.7	.9	-.3	.4	.9	.8	-.1	-.2	-.2	.1
26	.9	-.2	-.3	-.7	-.7	-.3	-.2	.4	-.5	.7	.0	-.4	-.3	-.4	-.5	.5	-.8	-.4	-.3	.1	.4	.8	.3
27	-.3	.9	.9	.7	.6	-.3	.7	-.5	.5	-.2	.7	.5	.5	.8	.7	-.8	.8	.7	.5	-.4	-.1	-.4	-.4
28	-.2	.7	.9	.7	.7	-.1	.8	-.6	.6	-.4	.7	.6	.5	.7	.6	-.6	.7	.7	.5	-.3	-.3	-.1	.1
29	-.3	.4	.6	.9	.8	-.5	.7	-.4	.7	-.5	.7	.4	.5	.5	.7	-.6	.5	.7	.7	-.4	-.2	-.5	-.4
30	-.3	.4	.6	.8	.9	-.1	.8	-.7	.9	-.4	.7	.6	.5	.5	.9	-.2	.4	.4	.6	.0	-.2	-.4	-.2
31	.3	-.1	.3	.2	.1	.9	.4	.1	.4	-.2	.2	-.2	-.4	-.8	-.2	.8	-.8	-.6	-.6	.8	.4	.6	.7
32	-.4	.4	.7	.8	.8	-.1	.9	-.5	.9	-.4	.7	.7	.5	.7	.7	-.4	.6	.9	.8	-.3	.0	.1	.0
33	.4	-.3	-.5	-.7	-.6	-.1	-.6	.9	-.9	.7	-.6	-.7	-.6	-.7	-.7	.4	-.6	-.7	-.6	-.1	.3	.6	.1
34	-.5	.3	.5	.6	.6	-.3	.7	-.8	.9	-.4	.6	.5	.5	.5	.6	-.3	.3	.6	.4	-.1	-.1	.1	.4
35	.6	.1	-.2	-.8	-.8	-.3	-.7	.6	-.2	.9	-.6	-.5	-.5	-.7	-.7	.6	-.8	-.7	-.6	-.4	.1	.8	-.1
36	-.4	.4	.4	.6	.6	-.3	.7	-.8	.9	-.2	.9	.5	.5	.7	.5	-.4	.5	.8	.7	-.1	-.2	-.2	.2
37	.0	.4	.4	.5	.7	.0	.8	-.7	.9	-.3	.8	.9	.8	.7	.6	-.4	.7	.6	.7	-.3	.0	-.1	-.1
38	.0	.1	.4	.6	.4	.0	.5	-.4	.5	-.2	.5	.8	.9	.4	.6	-.3	.4	.4	.6	-.3	-.1	.0	-.3
39	-.1	.6	.7	.6	.5	.0	.6	-.5	.8	-.3	.6	.7	.5	.9	.7	-.5	.9	.8	.7	-.5	-.4	-.5	-.4
40	-.3	.3	.6	.7	.7	-.3	.6	-.6	.6	-.4	.6	.4	.5	.5	.8	-.4	.5	.4	.5	-.2	-.3	-.4	-.1
41	.1	-.4	-.3	-.1	-.2	.7	-.1	.4	-.2	.3	.1	-.5	-.4	-.8	-.4	.9	-.9	-.8	-.7	.8	.3	.6	.9
42	-.2	.8	.7	.6	.6	-.2	.7	-.7	.7	-.4	.7	.6	.5	1.0	.8	-.5	.9	.8	.6	-.4	-.2	-.2	-.2
43	-.2	.5	.6	.5	.6	-.2	.9	-.6	.8	-.4	.8	.6	.4	.7	.7	-.2	.5	.9	.7	-.1	-.1	.0	.0
44	-.2	.6	.9	.9	.8	.2	.6	-.5	.7	-.2	.7	.4	.4	.4	1.0	.0	.7	.5	.8	.1	-.1	-.1	.2
45	.4	-.3	.0	-.2	-.2	.9	.5	-.3	.5	.2	.1	.0	.0	-1.0	-.4	.9	-.8	-.5	-.5	.6	.4	.8	.7
46	.7	.0	.0	-.8	-.7	.1	-.6	.5	-.4	.7	-.5	-.5	-.3	-.8	-.7	.5	-.7	-.7	-.7	.4	.9	.9	.3
47	.5	.0	-.3	-.4	-.4	.2	-.7	.7	-.8	.5	-.4	-.5	-.4	-.4	-.6	.6	-.5	-.6	-.4	.3	.4	.8	-.1
48	.1	.1	.5	.4	.6	.5	.8	-.7	.7	-.5	.4	.4	.3	-.1	.1	.0	-.3	-.2	.0	.5	.3	.7	.9

Table E14 – Standard deviation matrix using *exponential ratio* numeric equivalent.

Standard Desviation Matrix

Equivalent Numeric: Fixed (NC= .00 AM= 1.00 A = .84 AP= .51 DM= -1.00 D = -.84 DP= -.51) with Exponential Ratio series.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.08	.50	.37	.57	.00	.41	.33	.33	.00	.35	.31	.00	.37	.14	.42	.54
2	.33	.08	.38	.37	.50	.38	.41	.41	.33	.39	.50	.17	.08	.58	.50	.44
3	.44	.41	.33	.41	.47	.53	.44	.43	.44	.41	.46	.43	.43	.45	.73	.65
4	.33	.40	.64	.33	.33	.74	.56	.41	.42	.46	.54	.33	.65	.71	.61	.50
5	.44	.44	.31	.65	.70	.60	.39	.17	.44	.37	.44	.47	.50	.48	.57	.37
6	.44	.41	.40	.58	.61	.33	.48	.22	.40	.41	.70	.60	.33	.48	.54	.37
7	.44	.46	.43	.33	.46	.63	.34	.32	.32	.28	.51	.17	.44	.46	.70	.37
8	.37	.42	.32	.33	.63	.60	.34	.33	.34	.60	.47	.33	.61	.63	.66	.44
9	.44	.17	.41	.40	.39	.36	.37	.37	.43	.36	.48	.34	.58	.70	.59	.50
10	.41	.31	.38	.36	.44	.38	.44	.37	.38	.33	.49	.41	.21	.48	.59	.45
11	.34	.49	.44	.44	.44	.41	.41	.41	.44	.44	.33	.41	.49	.38	.47	.41
12	.33	.16	.36	.40	.43	.39	.39	.37	.32	.39	.47	.33	.40	.44	.58	.54
13	.44	.46	.44	.41	.44	.39	.36	.41	.42	.38	.47	.43	.34	.53	.67	.42
14	.41	.46	.49	.42	.49	.28	.37	.50	.37	.51	.43	.41	.50	.33	.62	.45
15	.48	.41	.56	.41	.47	.50	.28	.28	.00	.31	.44	.45	.37	.47	.33	.51
16	.60	.57	.61	.51	.49	.48	.37	.37	.45	.00	.44	.70	.58	.69	.49	.43
17	.50	.48	.65	.47	.41	.22	.17	.00	.33	.28	.41	.62	.37	.47	.40	.47
18	.46	.47	.52	.42	.35	.28	.28	.28	.28	.35	.31	.54	.47	.31	.65	.45
19	.45	.46	.56	.57	.41	.49	.32	.65	.44	.39	.48	.57	.44	.44	.49	.51
20	.47	.41	.41	.33	.37	.41	.56	.37	.52	.45	.38	.64	.46	.45	.55	.39
21	.44	.47	.39	.00	.00	.00	.00	.00	.00	.00	.41	.46	.50	.46	.46	.46
22	.49	.67	.68	.33	.65	.77	.46	.44	.33	.60	.48	.59	.59	.64	.49	.41
23	.47	.45	.63	.35	.28	.28	.28	.28	.28	.35	.46	.47	.48	.48	.43	.44
24	.17	.48	.35	.33	.33	.33	.00	.00	.00	.33	.46	.48	.46	.43	.46	.65
25	.08	.49	.44	.48	.33	.39	.33	.00	.00	.46	.48	.44	.37	.47	.44	.48
26	.57	.62	.66	.68	.67	.46	.49	.39	.34	.43	.48	.42	.47	.48	.72	.61
27	.60	.61	.58	.58	.46	.44	.50	.50	.60	.33	.46	.70	.44	.51	.69	.51
28	.35	.57	.46	.57	.46	.46	.46	.46	.57	.46	.53	.60	.44	.53	.51	.50
29	.17	.46	.44	.44	.44	.44	.50	.50	.44	.44	.69	.44	.44	.49	.40	.49
30	.43	.50	.53	.44	.46	.33	.33	.44	.44	.44	.53	.44	.44	.49	.43	.51
31	.35	.49	.59	.61	.50	.32	.32	.31	.38	.50	.51	.37	.65	.50	.41	.65
32	.33	.44	.52	.41	.28	.28	.17	.17	.00	.28	.48	.44	.59	.44	.43	.50
33	.41	.42	.67	.38	.41	.40	.38	.38	.45	.43	.45	.31	.44	.53	.49	.49
34	.50	.41	.47	.41	.41	.50	.35	.00	.00	.33	.46	.54	.45	.50	.46	.48
35	.57	.39	.42	.43	.44	.41	.48	.41	.50	.65	.48	.23	.49	.50	.57	.50
36	.42	.53	.61	.49	.46	.57	.46	.46	.62	.46	.51	.69	.48	.51	.46	.49
37	.33	.28	.41	.28	.28	.28	.28	.28	.28	.28	.62	.37	.28	.38	.42	.43
38	.36	.28	.33	.41	.35	.17	.17	.17	.17	.35	.45	.44	.17	.44	.49	.45
39	.40	.41	.31	.31	.17	.17	.31	.31	.31	.17	.47	.41	.37	.48	.60	.42
40	.08	.49	.28	.17	.17	.17	.17	.17	.17	.17	.50	.50	.41	.48	.46	.47
41	.28	.45	.44	.43	.46	.53	.32	.27	.32	.49	.51	.65	.47	.49	.67	.56
42	.41	.41	.50	.44	.41	.33	.41	.44	.44	.41	.42	.44	.44	.49	.73	.49
43	.38	.35	.57	.41	.28	.28	.28	.17	.25	.17	.50	.54	.28	.49	.48	.50
44	.05	.51	.44	.44	.33	.33	.35	.35	.28	.17	.43	.50	.28	.46	.44	.44
45	.45	.59	.31	.39	.44	.38	.32	.41	.43	.39	.51	.53	.39	.45	.67	.44
46	.57	.34	.67	.42	.42	.41	.41	.41	.48	.43	.53	.43	.48	.47	.65	.61
47	.50	.42	.42	.51	.48	.46	.35	.31	.37	.38	.41	.46	.48	.41	.57	.57
48	.71	.60	.42	.46	.48	.49	.46	.44	.46	.31	.44	.44	.69	.67	.71	.68

	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	.19	.81	.31	.41	.29	.00	.33	.48	.40	.00	.56	.42	.32	.33	.37	.32
2	.51	.71	.62	.44	.54	.42	.51	.48	.62	.40	.67	.70	.48	.45	.38	.50
3	.77	.65	.63	.57	.52	.60	.47	.51	.44	.17	.69	.74	.41	.43	.63	.49
4	.61	.50	.33	.42	.71	.17	.75	.38	.59	.44	.62	.68	.69	.63	.41	.74
5	.38	.52	.50	.31	.54	.58	.48	.42	.50	.46	.49	.44	.37	.54	.59	.59
6	.69	.62	.44	.44	.61	.35	.75	.42	.59	.46	.74	.76	.48	.49	.60	.67
7	.67	.57	.47	.41	.59	.42	.72	.41	.44	.39	.68	.77	.41	.47	.66	.63
8	.67	.71	.47	.43	.61	.65	.61	.45	.56	.44	.85	.82	.32	.43	.43	.64
9	.65	.72	.49	.41	.44	.39	.66	.41	.55	.63	.71	.74	.41	.42	.49	.47
10	.67	.63	.65	.57	.47	.53	.74	.44	.60	.63	.70	.80	.43	.32	.49	.46
11	.46	.33	.45	.45	.38	.41	.45	.44	.44	.41	.50	.45	.16	.42	.44	.46
12	.77	.67	.62	.60	.74	.39	.68	.63	.62	.61	.82	.73	.42	.47	.55	.71
13	.49	.61	.64	.65	.56	.32	.44	.51	.37	.42	.48	.59	.63	.64	.70	.61
14	.45	.38	.62	.32	.40	.48	.41	.43	.47	.49	.68	.68	.43	.42	.67	.51
15	.34	.84	.41	.63	.40	.28	.34	.46	.65	.47	.65	.65	.48	.43	.53	.34
16	.41	.37	.61	.38	.46	.28	.65	.62	.49	.62	.46	.51	.63	.63	.37	.67
17	.33	.46	.38	.41	.35	.28	.33	.61	.43	.51	.67	.19	.41	.41	.52	.16
18	.41	.33	.44	.59	.61	.00	.47	.40	.46	.44	.16	.42	.44	.46	.37	.44
19	.43	.74	.33	.34	.49	.46	.43	.48	.47	.41	.63	.42	.41	.41	.35	.33
20	.38	.42	.63	.33	.39	.38	.40	.49	.45	.38	.48	.42	.39	.57	.44	.38
21	.42	.64	.53	.41	.33	.28	.19	.58	.42	.54	.63	.47	.46	.46	.58	.41
22	.59	.47	.42	.56	.71	.33	.78	.49	.59	.71	.62	.67	.75	.75	.33	.16
23	.33	.49	.57	.63	.34	.61	.44	.46	.41	.52	.67	.71	.43	.43	.61	.35
24	.46	.42	.54	.59	.43	.00	.49	.33	.48	.51	.41	.41	.47	.47	.41	.46
25	.32	.48	.69	.38	.40	.37	.16	.61	.33	.59	.40	.08	.08	.33	.46	.33
26	.48	.87	.80	.57	.68	.38	.80	.65	.51	.33	.65	.69	.42	.42	.63	.59
27	.46	.07	.65	.38	.41	.41	.43	.44	.41	.82	.33	.17	.65	.69	.54	.41
28	.41	.42	.61	.39	.49	.44	.43	.44	.43	.65	.43	.33	.66	.66	.63	.32
29	.41	.40	.69	.56	.47	.33	.43	.46	.68	.50	.71	.68	.33	.35	.60	.42
30	.42	.48	.57	.37	.43	.33	.49	.46	.78	.48	.70	.68	.34	.33	.60	.32
31	.65	.51	.33	.33	.64	.44	.64	.41	.79	.62	.82	.82	.74	.76	.33	.67
32	.32	.46	.61	.33	.40	.28	.42	.46	.48	.49	.70	.41	.31	.31	.31	.33
33	.43	.60	.49	.59	.50	.33	.51	.48	.49	.66	.65	.51	.42	.47	.39	.49
34	.32	.46	.60	.42	.46	.33	.44	.46	.44	.50	.62	.48	.48	.48	.54	.50
35	.63	.61	.49	.47	.51	.59	.54	.41	.28	.49	.69	.61	.32	.32	.54	.42
36	.34	.67	.65	.44	.45	.41	.33	.42	.49	.51	.51	.70	.41	.46	.69	.34
37	.40	.45	.42	.42	.45	.28	.32	.49	.41	.00	.47	.44	.41	.31	.42	.31
38	.45	.45	.39	.28	.41	.00	.44	.63	.44	.00	.56	.44	.44	.44	.00	.43
39	.32	.08	.48	.38	.44	.33	.43	.47	.38	.33	.38	.37	.45	.48	.00	.45
40	.44	.47	.47	.41	.41	.33	.33	.42	.80	.50	.69	.48	.42	.42	.48	.47
41	.73	.51	.45	.39	.65	.35	.56	.45	.69	.55	.67	.71	.63	.65	.41	.67
42	.46	.32	.67	.60	.46	.44	.47	.44	.48	.63	.32	.41	.47	.47	.44	.42
43	.32	.47	.68	.65	.46	.33	.43	.63	.37	.35	.39	.28	.41	.38	.44	.08
44	.53	.51	.59	.38	.55	.00	.59	.48	.44	.44	.46	.15	.08	.32	.57	.52
45	.65	.62	.33	.32	.71	.41	.70	.41	.54	.62	.69	.74	.64	.69	.08	.39
46	.68	.51	.62	.55	.48	.43	.65	.61	.77	.65	.80	.82	.44	.50	.73	.48
47	.62	.57	.54	.65	.48	.00	.47	.65	.57	.48	.65	.48	.44	.46	.37	.42
48	.68	.78	.29	.43	.62	.65	.29	.37	.45	.67	.75	.69	.64	.36	.35	.32

	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1	.44	.19	.38	.31	.38	.41	.41	.07	.49	.39	.30	.41	.44	.45	.54	.59
2	.64	.30	.40	.59	.47	.63	.63	.48	.72	.65	.63	.51	.35	.43	.16	.61
3	.47	.42	.05	.50	.66	.63	.66	.48	.64	.72	.47	.49	.59	.42	.33	.75
4	.61	.65	.68	.74	.59	.65	.56	.61	.62	.64	.74	.44	.43	.40	.43	.42
5	.65	.67	.32	.45	.41	.37	.45	.45	.46	.47	.41	.49	.44	.45	.32	.44
6	.43	.76	.47	.60	.48	.46	.80	.51	.74	.65	.72	.48	.22	.63	.35	.57
7	.67	.59	.72	.82	.59	.71	.46	.65	.69	.45	.48	.48	.43	.43	.43	.41
8	.57	.61	.63	.64	.67	.61	.44	.48	.43	.47	.77	.49	.42	.37	.43	.16
9	.42	.43	.40	.75	.44	.44	.45	.43	.38	.40	.47	.51	.44	.46	.32	.63
10	.72	.44	.41	.68	.48	.48	.41	.48	.65	.44	.44	.49	.54	.39	.42	.57
11	.46	.44	.41	.46	.46	.48	.33	.43	.49	.47	.41	.47	.48	.45	.49	.50
12	.63	.74	.72	.79	.65	.63	.45	.43	.37	.47	.44	.47	.61	.39	.41	.70
13	.59	.63	.48	.62	.49	.50	.46	.46	.36	.46	.45	.47	.65	.25	.41	.52
14	.48	.49	.49	.48	.42	.42	.46	.68	.73	.41	.43	.47	.69	.28	.70	.59
15	.45	.42	.50	.42	.41	.47	.49	.41	.61	.71	.44	.42	.39	.35	.56	.41
16	.57	.41	.42	.50	.41	.39	.38	.59	.58	.54	.62	.42	.39	.54	.33	.46
17	.68	.33	.53	.32	.21	.48	.43	.50	.63	.44	.32	.47	.61	.46	.76	.61
18	.63	.46	.46	.43	.45	.44	.30	.48	.41	.40	.31	.41	.49	.44	.61	.44
19	.67	.35	.67	.16	.68	.46	.64	.63	.32	.47	.92	.74	.33	.43	.32	.17
20	.67	.33	.50	.41	.44	.53	.59	.52	.74	.61	.60	.37	.64	.35	.40	.62
21	.42	.42	.51	.41	.40	.46	.44	.45	.71	.61	.30	.41	.61	.28	.65	.52
22	.40	.31	.48	.34	.41	.59	.48	.84	.42	.45	.76	.59	.41	.48	.50	.41
23	.49	.43	.51	.32	.43	.50	.41	.42	.57	.44	.42	.42	.47	.28	.47	.52
24	.46	.47	.50	.49	.62	.62	.65	.32	.49	.44	.67	.67	.41	.28	.51	.45
25	.33	.31	.49	.32	.39	.42	.40	.08	.54	.44	.15	.32	.57	.37	.56	.50
26	.64	.65	.43	.74	.57	.45	.49	.51	.48	.32	.49	.50	.54	.49	.66	.48
27	.59	.71	.65	.43	.48	.48	.32	.43	.33	.33	.42	.71	.51	.57	.71	.51
28	.47	.48	.51	.42	.47	.48	.42	.68	.67	.42	.42	.68	.65	.45	.69	.67
29	.66	.41	.51	.43	.66	.48	.64	.41	.64	.56	.41	.42	.51	.37	.51	.44
30	.42	.15	.51	.42	.44	.46	.68	.16	.66	.53	.53	.39	.56	.41	.60	.60
31	.73	.61	.62	.73	.65	.57	.32	.61	.35	.44	.49	.47	.32	.44	.46	.42
32	.72	.08	.51	.41	.43	.50	.42	.41	.57	.48	.08	.32	.48	.46	.79	.74
33	.33	.17	.42	.49	.50	.53	.50	.43	.67	.53	.50	.53	.39	.45	.48	.28
34	.43	.33	.53	.48	.50	.50	.51	.47	.65	.67	.46	.46	.64	.57	.71	.42
35	.49	.79	.33	.67	.48	.48	.41	.43	.57	.30	.40	.44	.57	.57	.44	.57
36	.33	.08	.67	.33	.48	.48	.41	.43	.51	.46	.32	.40	.52	.44	.71	.38
37	.42	.08	.50	.19	.33	.34	.41	.41	.51	.41	.38	.42	.48	.42	.69	.57
38	.51	.51	.41	.48	.34	.33	.42	.39	.48	.44	.44	.46	.48	.28	.70	.48
39	.51	.32	.48	.41	.40	.48	.33	.41	.51	.16	.33	.42	.51	.51	.60	.51
40	.49	.47	.51	.47	.68	.48	.63	.34	.58	.51	.70	.55	.41	.48	.51	.54
41	.44	.65	.43	.74	.59	.57	.43	.51	.33	.33	.43	.50	.33	.41	.48	.33
42	.50	.41	.51	.42	.46	.48	.05	.34	.51	.33	.32	.48	.51	.65	.61	.59
43	.47	.34	.58	.31	.46	.44	.42	.41	.50	.50	.33	.36	.47	.47	.78	.61
44	.61	.53	.44	.42	.67	.44	.59	.05	.35	.31	.48	.43	.47	.57	.76	.74
45	.65	.64	.38	.81	.85	.65	.07	.66	.33	.32	.60	.60	.70	.42	.31	.43
46	.50	.55	.50	.69	.51	.48	.43	.50	.64	.42	.42	.41	.49	.33	.08	.61
47	.60	.32	.43	.70	.50	.49	.49	.49	.46	.48	.47	.51	.44	.46	.43	.57
48	.56	.42	.59	.70	.64	.41	.88	.74	.94	.82	.91	.76	.68	.65	.43	.33

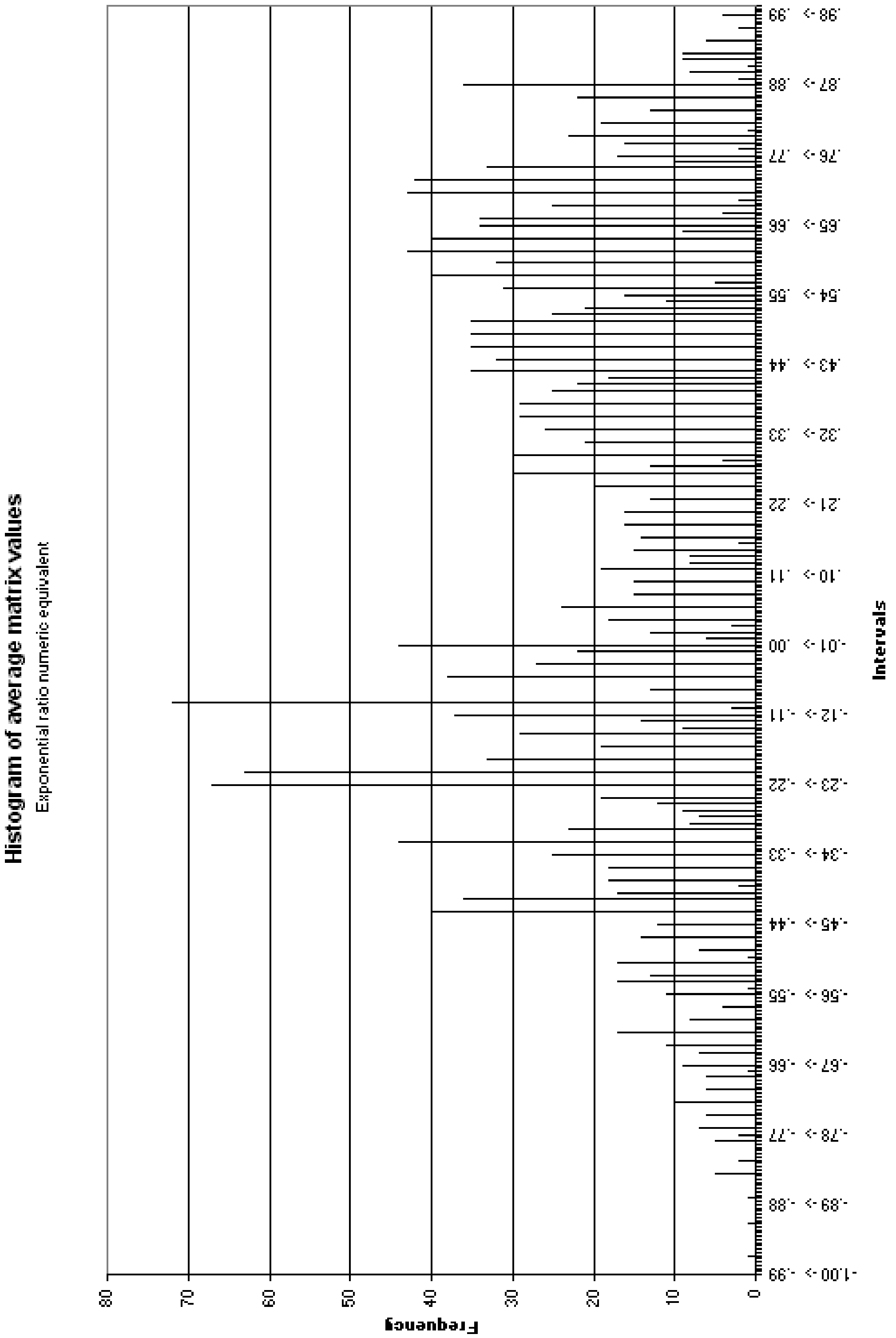

Figure E5 — Histogram of General Average Matrix values using *exponential ratio* numeric equivalent.

Table E15 – Energy of activation of each concept using *exponential ratio* numeric equivalent (increasing order).

Activation Energy

Ordered Answers Concerning Activation Energy
Numeric Equivalent: *Exponential Ratio* series.

Concept	Activ.+	Concept	Activ.-	Concept	BeAct.+	Concept	BeAct.-
13 ==>	9.6	33 ==>	-14.6	8 ==>	8.3	33 ==>	-19.8
33 ==>	9.7	10 ==>	-13.9	7 ==>	8.7	42 ==>	-14.7
47 ==>	10.0	46 ==>	-13.1	33 ==>	9.4	35 ==>	-13.0
5 ==>	11.0	35 ==>	-13.1	10 ==>	9.7	39 ==>	-12.9
35 ==>	11.5	26 ==>	-12.9	22 ==>	9.9	29 ==>	-11.9
10 ==>	11.8	6 ==>	-12.4	35 ==>	10.4	41 ==>	-11.7
38 ==>	12.3	9 ==>	-12.2	6 ==>	10.5	43 ==>	-11.7
6 ==>	12.3	12 ==>	-12.1	31 ==>	11.0	30 ==>	-11.6
41 ==>	12.9	2 ==>	-12.1	13 ==>	11.1	40 ==>	-11.4
26 ==>	13.4	3 ==>	-11.8	46 ==>	11.4	44 ==>	-10.0
2 ==>	13.9	13 ==>	-11.6	45 ==>	12.0	37 ==>	-8.8
24 ==>	14.1	47 ==>	-10.9	5 ==>	12.1	45 ==>	-8.7
9 ==>	14.1	41 ==>	-10.0	24 ==>	12.1	34 ==>	-8.6
40 ==>	15.0	8 ==>	-9.4	11 ==>	13.1	19 ==>	-8.4
46 ==>	15.2	45 ==>	-8.9	9 ==>	13.5	24 ==>	-8.3
3 ==>	15.3	31 ==>	-8.7	4 ==>	13.5	11 ==>	-8.3
11 ==>	15.3	29 ==>	-8.2	2 ==>	13.8	47 ==>	-8.2
37 ==>	15.4	7 ==>	-8.0	26 ==>	13.8	14 ==>	-8.2
18 ==>	15.4	22 ==>	-7.7	3 ==>	13.9	2 ==>	-8.0
12 ==>	15.6	4 ==>	-7.7	19 ==>	14.1	48 ==>	-8.0
16 ==>	15.9	27 ==>	-7.6	16 ==>	14.9	31 ==>	-8.0
34 ==>	16.0	48 ==>	-7.3	42 ==>	14.9	36 ==>	-8.0
14 ==>	16.3	5 ==>	-7.2	48 ==>	15.1	26 ==>	-7.9
39 ==>	16.3	42 ==>	-6.9	14 ==>	15.3	18 ==>	-7.8
21 ==>	16.5	30 ==>	-6.7	12 ==>	15.4	13 ==>	-7.8
45 ==>	16.5	14 ==>	-6.5	38 ==>	15.8	32 ==>	-7.6
30 ==>	16.6	18 ==>	-6.2	41 ==>	16.0	27 ==>	-7.5
31 ==>	16.7	11 ==>	-6.1	44 ==>	16.6	38 ==>	-7.3
43 ==>	16.8	36 ==>	-6.1	39 ==>	17.5	12 ==>	-7.2
42 ==>	17.0	24 ==>	-6.1	20 ==>	17.9	28 ==>	-7.1
29 ==>	17.1	28 ==>	-6.0	18 ==>	17.9	3 ==>	-7.1
36 ==>	17.2	34 ==>	-5.9	1 ==>	18.2	23 ==>	-6.8
1 ==>	17.3	40 ==>	-5.8	15 ==>	18.5	17 ==>	-6.7
15 ==>	17.5	39 ==>	-5.7	27 ==>	19.0	21 ==>	-6.6
32 ==>	17.9	32 ==>	-5.4	25 ==>	19.2	15 ==>	-5.2
23 ==>	17.9	19 ==>	-5.3	43 ==>	19.2	4 ==>	-5.2
44 ==>	18.2	23 ==>	-5.3	40 ==>	19.2	46 ==>	-5.1
4 ==>	18.6	15 ==>	-5.0	21 ==>	19.3	1 ==>	-4.5
20 ==>	18.7	25 ==>	-5.0	30 ==>	19.4	6 ==>	-4.5
25 ==>	19.0	43 ==>	-4.7	37 ==>	19.8	25 ==>	-4.2
7 ==>	19.1	44 ==>	-4.4	29 ==>	19.9	10 ==>	-4.2
8 ==>	19.1	1 ==>	-4.4	47 ==>	22.0	16 ==>	-3.9
27 ==>	19.2	37 ==>	-4.2	28 ==>	22.4	20 ==>	-3.9
22 ==>	19.3	21 ==>	-4.2	32 ==>	22.7	5 ==>	-3.7
28 ==>	19.3	16 ==>	-4.1	17 ==>	23.6	22 ==>	-3.7
48 ==>	19.7	17 ==>	-3.9	36 ==>	23.6	7 ==>	-3.1
17 ==>	20.0	38 ==>	-3.5	23 ==>	24.5	9 ==>	-2.7
19 ==>	22.0	20 ==>	-3.5	34 ==>	25.1	8 ==>	-2.5